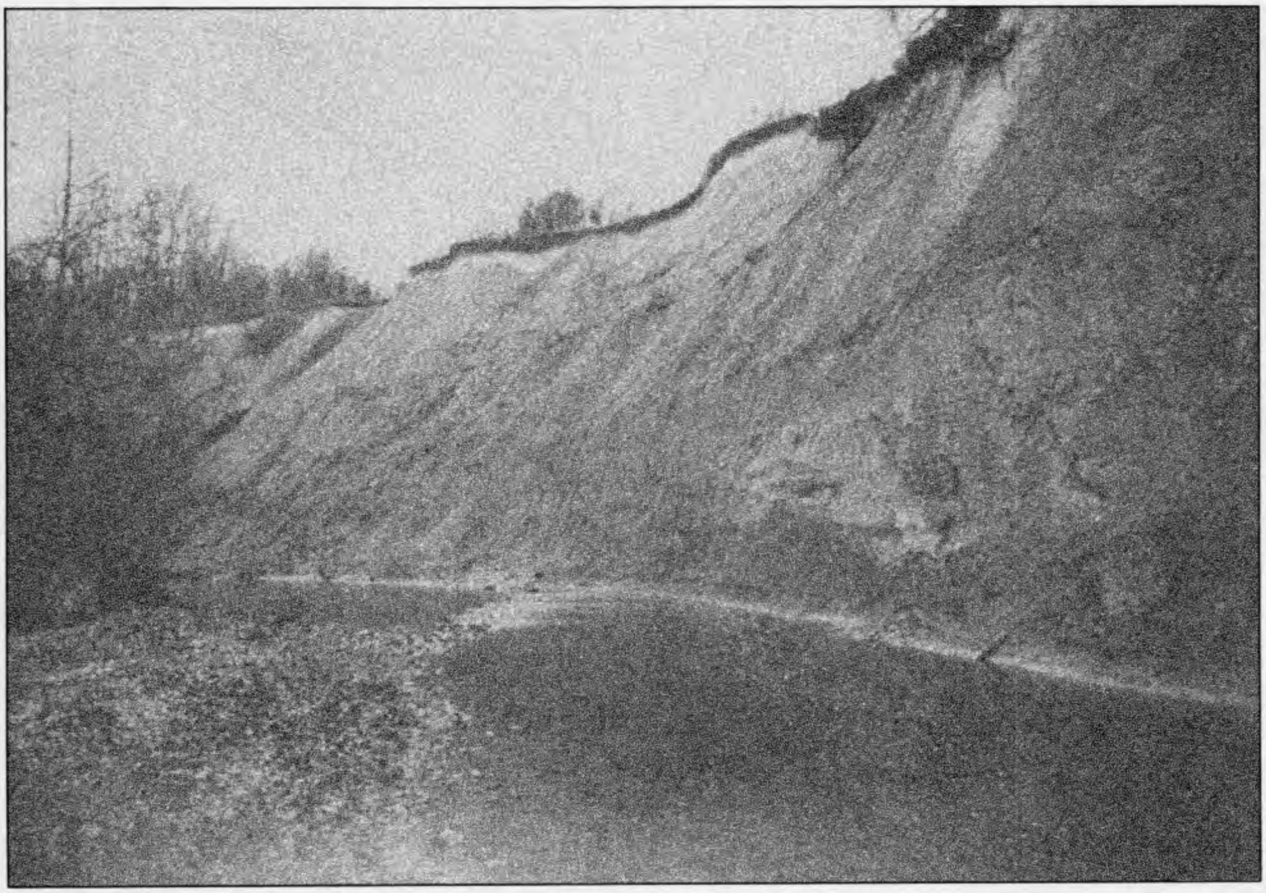
GUIDEBOOK NO. 10

# THE SANGAMONIAN-WISCONSINAN TRANSITION IN SOUTHWESTERN OHIO AND SOUTHEASTERN INDIANA

by

Robert D. Hall
and others



prepared for the 1992 Annual Meeting
of the Geological Society of America

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# THE SANGAMONIAN-WISCONSINAN TRANSITION IN SOUTHWESTERN OHIO AND SOUTHEASTERN INDIANA

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Field Trips 5 and 17 for the Annual Meeting
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Columbus
1992

This volume is dedicated to the memory of

Ansel M. Gooding (1924-1976)
and
Richard P. Goldthwait (1911-1992)

who greatly influenced thought about the Pleistocene
in the Midwest and beyond.

Typesetting and layout: Lisa Van Doren
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and Robert L. Stewart

Cover illustration: Stream cut along Bantas Fork (Stop 3).
See figure 14.

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# THE SANGAMONIAN-WISCONSINAN TRANSITION IN SOUTHWESTERN OHIO AND SOUTHEASTERN INDIANA

by

**Robert D. Hall**
**and others**

## INTRODUCTION

The late-Pleistocene stratigraphic framework for southeastern Indiana and southwestern Ohio (table 1) was developed primarily by Gooding (1963, 1975), Goldthwait and others (1981), and graduate students at Miami University working under the supervision of Dr. D. Perry Stewart. The purpose of this field trip is to reinterpret that framework, which is centered on the Sangamonian-Wisconsinan transition, from analyses of paleosols, amino acids, C-14 and paleomagnetic measurements, and other properties.

TABLE 1.—*Previously established stratigraphy of eastern Indiana and western Ohio developed primarily by Gooding (1963, 1975), Goldthwait and others (1981), and graduate students at Miami University under D. P. Stewart*

| CHRONOSTATIGRAPHY | | LITHOSTRATIGRAPHY |
|---|---|---|
| WISCONSINAN STAGE | LATE | Knightstown Till<br>Crawfordsville Till<br>Shelbyville Till<br>CONNERSVILLE INTERSTADIAL SEDIMENTS<br>Fayette Till |
| | MIDDLE | SIDNEY INTERSTADIAL SEDIMENTS;<br>SIDNEY GEOSOL<br>Fairhaven Till |
| | EARLY | NEW PARIS INTERSTADIAL SEDIMENTS<br>Whitewater Till |
| SANGAMONIAN STAGE | | SANGAMONIAN SEDIMENTS;<br>SANGAMON GEOSOL |
| ILLINOIAN STAGE | | Richmond Till<br>ABINGTON INTERSTADIAL SEDIMENTS<br>Centerville Till |

The Whitewater Till has been considered the basal unit of the Wisconsinan sequence in this area because, at some localities, it (1) overlies a soil believed to be the Sangamon Geosol or sediments interpreted as Sangamonian; and (2) underlies nonglacial, predominantly organic sediments (New Paris) that yield infinite radiocarbon ages (Gooding, 1963, 1975; Goldthwait and others, 1981; Fullerton, 1986; Vincent and Prest, 1987). These relationships were argued to be present at the American Aggregates pit in Richmond, Indiana (Stop 1) (fig. 1), the type section for the Whitewater Till and the New Paris sediments (Gooding, 1963). Although no paleosol, per se, is present beneath the Whitewater Till, the underlying unit is oxidized till with oxidized joints that has been interpreted as a deeply truncated Sangamon weathering profile in the Illinoian Richmond Till.

The stratigraphic framework also includes the Fairhaven Till, the nonglacial Sidney sediments, and the Sidney Geosol, all assigned to the middle Wisconsinan on the basis of (1) the conclusion that the Fairhaven Till overlies the New Paris sediments, and (2) radiocarbon dates of about 23,000 years B.P. from organic sediments at the top of the Sidney Geosol. Exposures of the Fairhaven Till have been claimed in this area from New Paris south to Fairhaven and Camden and east to Bantas Fork (Goldthwait and others, 1981).

However, the extent, and indeed the very existence, of early and middle Wisconsinan ice advances by the Miami Sublobe of the Laurentide ice sheet into southwestern Ohio and southeastern Indiana are being questioned (Clark and Lea, 1986; Hall and others, 1992; Miller and others, 1992). At the American Aggregates pit, data from amino acid racemization reaction (AAR) studies of molluscan shells collected from the New Paris sediments are more compatible with an early Illinoian age or older for these sediments and for the underlying Whitewater Till (Miller and others, 1992). On the basis of preliminary correlation of the Whitewater Till at the American Aggregates pit with a better dated till at New Paris, Hall and others (1992) tentatively concluded that the Whitewater Till is Illinoian. If so, the underlying till with oxidized joints at American Aggregates is probably pre-Illinoian.

The New Paris section (Stop 2) is especially important in re-evaluating the stratigraphy of the area because it contains two well-developed paleosols. The upper paleosol was considered the Sidney Geosol by previous workers (Gooding, 1975; Goldthwait and others, 1981); however, the lower paleosol was apparently not recognized. Between the two paleosols are two tills separated by a silt. Previous workers have interpreted the tills as the Whitewater and Fairhaven Tills. We believe that the two paleosols, because of their development, are the Sangamon Geosol and the Yarmouth Geosol. If so, the "Fairhaven" and "Whitewater" Tills at New Paris (and the Whitewater Till at the American Aggregates pit by correlation) are Illinoian (Hall and others, 1992).

At Bantas Fork (Stop 3), a diamicton considered to be the Fairhaven Till (Goldthwait and others, 1981) rests upon an organic silt containing molluscs and wood considered to be the New Paris sediments. The wood yielded a radiocarbon date of 44,800±700 years B.P. However, Miller and others (1992 and in this report) present amino acid data that suggest this silt is pre-Wisconsinan. Furthermore, a paleosol developed in the "Fairhaven" diamicton is best interpreted as a truncated Sangamon Geosol, making the diamicton Illinoian.

On the field trip we will visit and re-examine some of the classic sites of southeastern Indiana and southwestern Ohio and present evidence that (1) the Whitewater Till, the New Paris sediments, and the Fairhaven Till are pre-Wisconsinan, and (2) the concept of the Sidney Geosol as it originated (Forsyth, 1965; Gooding, 1975) needs re-evaluation because most so-called Sidney Geosol profiles are probably the Sangamon Geosol. We will visit the American Aggregates Richmond pit, New Paris, and Bantas Fork. At the appropriate localities we will discuss the amino acid data, problems of

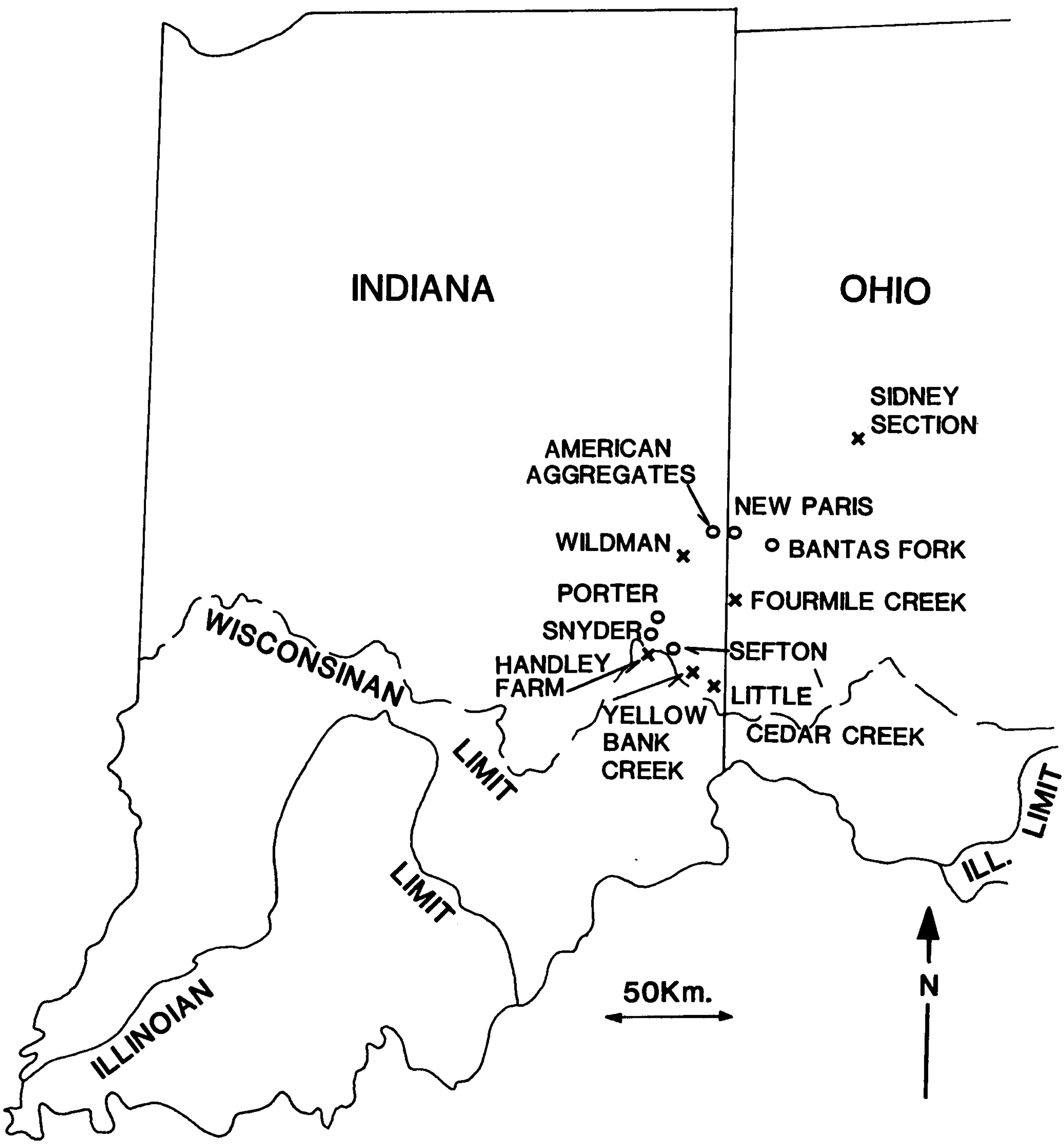


FIGURE 1.—Location map. Circles indicate field-trip stops. X's indicate other locations mentioned in text. See back cover for a more detailed map of field-trip stops.

correlating tills, and interpretation of paleosols. Stops will also include two localities with paleosol profiles widely accepted as the Sangamon Geosol so that participants can compare paleosol characteristics with profiles at New Paris and Bantas Fork. At Snyder Farm (Stop 4), the Sangamon Geosol developed under moderately good drainage in a till; at Sefton Farm (Stop 5) it developed under very poor drainage in probable fluvial overbank deposits. If time permits, a stop will be made at the Porter Farm site. This locality is unusual in that fossil fish, mammals, and molluscs have been recovered from an upper till interpreted by Gooding (1963) as the Whitewater Till. However, preliminary AAR data of shell protein from gastropods recovered from this deposit suggest a much older age. Also at the Porter locality, a lower till rests upon lake sediments that have reversed polarity.

## AMINOSTRATIGRAPHY

Amino acid racemization (AAR) of isoleucine from fossil molluscan shell protein has become a widely used tool in the resolution of pre-Wisconsinan stratigraphic problems in North American Quaternary nonmarine sequences (Miller and others, 1987; Clark and others, 1989; Miller and McCoy, 1991). The technique is based on reactions which over time epimerize L-isoleucine (Ile) to its nonprotein diastereomer, D-alloisoleucine (aIle). The reaction is reversible, and over time eventually reaches an equilibrium value of about 1.30 (Clark and others, 1989). The epimerization rate is primarily dependent upon the molluscan taxon involved and the effective diagenetic temperature history of the sample. Direct use of amino acid epimerization ratios as an indicator of relative age can be achieved in situations in which the same taxa are being compared from shells within a restricted geographic area with similar modern temperatures. It is assumed that if the sites have remained buried below the depth of seasonal temperature changes, they probably will have been subjected to similar temperature histories. Under these circumstances, it is presumed that discordant aIle/Ile ratios between samples of the same taxon from different sites are due to differences in age. The geographic proximity of the sites to be visited on this trip appear to fit these conditions.

Five taxa, *Pisidium, Catinella, Fossaria, Sphaerium,* and *Succinea,* from seven sites have been used in this study. The aIle/Ile ratio in the total acid hydrolysate (free and peptide-bound amino acids) for these taxa are listed in table 2 and plotted in figure 2. Samples from radiocarbon-dated late Wisconsinan (*ca.* 20,000 years B.P.) horizons at Yellow Bank Creek and Little Cedar Creek, material from magnetically reversed sediments at Handley Farm, and from beneath the Sidney Geosol at the Sidney section (Miller and others, 1992) have been included to provide a basis for evaluating the relative age implications of the aIle/Ile ratios from Bantas Fork, American Aggregates, and Porter Farm.

The lowest aIle/Ile ratios are from the Late Wisconsinan samples; the highest aIle/Ile ratios are from samples associated with magnetically reversed sediments (>730,000 years B.P.) at Handley Farm. These ratios are in agreement with values obtained for the same taxa from sediments at other sites in Indiana and Illinois associated with the Matuyama Reversed Polarity Chronozone (Palmer and others, 1991). The aIle/Ile ratios obtained from Bantas Fork and the Sidney section are similar to values obtained from Illinoian-age samples at other sites in Ohio, Indiana, and Illinois (Miller and others, 1992). The American Aggregates and Porter Farm aIle/Ile ratios appear to be intermediate between those from interpreted Illinoian-age deposits and the magnetically reversed horizon at Handley Farm, suggesting that they are early Illinoian or pre-Illinoian in age.

TABLE 2.—*Summary of aIle/Ile total hydrolysate[1] from fossil molluscan shell in the study area*

| Locality[2]/age | AGL no.[3] | Taxon | No. | Mean | Standard deviation +/- |
|---|---|---|---|---|---|
| Yellow Bank Creek ~20,000 Y.B.P. | 435 | *Catinella* | 2 | 0.071 | 0.020 |
| | 437 | *Fossaria* | 1 | 0.054 | 0.000 |
| | 442 | *Fossaria* | 1 | 0.047 | 0.000 |
| Little Cedar Creek ~20,000 Y.B.P. | 311 | *Catinella* | 1 | 0.080 | 0.000 |
| Sidney section | 785 | *Succinea* | 1 | 0.22 | 0.000 |
| | 787 | *Catinella* | 1 | 0.23 | 0.000 |
| Bantas Fork | 122 | *Catinella* | 3 | 0.19 | 0.02 |
| | 714 | *Catinella* | 2 | 0.22 | 0.01 |
| American Aggregates | 715 | *Catinella* | 2 | 0.50 | 0.020 |
| | 1721[4] | *Catinella* | 1 | 0.55 | 0.000 |
| | 125 | *Catinella* | 2 | 0.50 | 0.003 |
| | 1016 | *Catinella* | 3 | 0.53 | 0.06 |
| | 1017 | *Fossaria* | 3 | 0.46 | 0.01 |
| Handley Farm | 1178 | *Catinella* | 1 | 0.84 | 0.000 |
| | 1724 | *Catinella* | 1 | 0.73 | 0.000 |
| | 1177 | *Succinea* | 2 | 0.78 | 0.01 |
| | 1725 | *Succinea* | 2 | 0.78 | 0.09 |
| | 1726 | *Sphaerium* | 1 | 0.61 | 0.000 |
| Porter Farm | 1828[5] | *Sphaerium* | 2 | 0.57 | 0.003 |

[1]Data plotted in figure 2.
[2]See figure 1 for localities.
[3]AGL, Amino Acid Geochronology Laboratory, University of Massachusetts.
[4]Sample from New Paris sediments at section AA-2.
[5]Samples from soil horizon 5D at section PO-1.

## MAGNETOSTRATIGRAPHY

Paleomagnetic measurements have become important as an approach to age determinations of Quaternary sediments. Under the best conditions, where thick sections of sediment were deposited at a high rate of sedimentation, measurements of declination and inclination may show gradual secular changes in the magnetic field. In areas such as those described here, the deposition of silts and clays over short periods separated by glacial advances do not offer the resolution necessary to trace the secular variation in the field. Nonetheless, measurements of the declination and inclination can indicate whether magnetic character of the sediments was formed in a period of normal or reversed polarity. These are the Brunhes Normal Epoch and the Matuyama Reversed Epoch, based on the expected ages and the resolution of the Quaternary sediments described here.

The time that the magnetic signature is acquired by the sediments may be other than the time of deposition. Postdepositional remanent magnetization may be due to physical changes such as compaction or de-watering or due to chemical changes such as oxidation or reduction. Most physical changes are expected to occur close to the time of deposition, but chemical changes may occur long after deposition through the movement of ground water or through soil-forming processes.

Two sites on this trip were sampled for paleomagnetic measurements: the American Aggregates pit and the Porter Farm locality. At the American Aggregates pit, 18 samples of the New Paris silt (near site AA-2, see fig. 4) were tested for natural remanent magnetism (NRM) and were put through alternating field (AF) demagnetization to remove overprints. The samples all showed consistent normal magnetization which remained unchanged through demagnetization. This very hard magnetic component may be the original magnetic signature from the time of deposition, but oxidation stains in the silts suggest the magnetic signature may be due to postdepositional chemical alterations that may be quite recent.

At Porter Farm, 10 samples from clay within the upper till (profile PO-1, soil horizon 5D) were normally magnetized; 37 samples from clay beneath the lower till at Porter Farm (profile PO-2, 750 cm) were reversed, suggesting the clay was deposited during the Matuyama Reversed Epoch and has a minimum age of 730,000 years B.P.

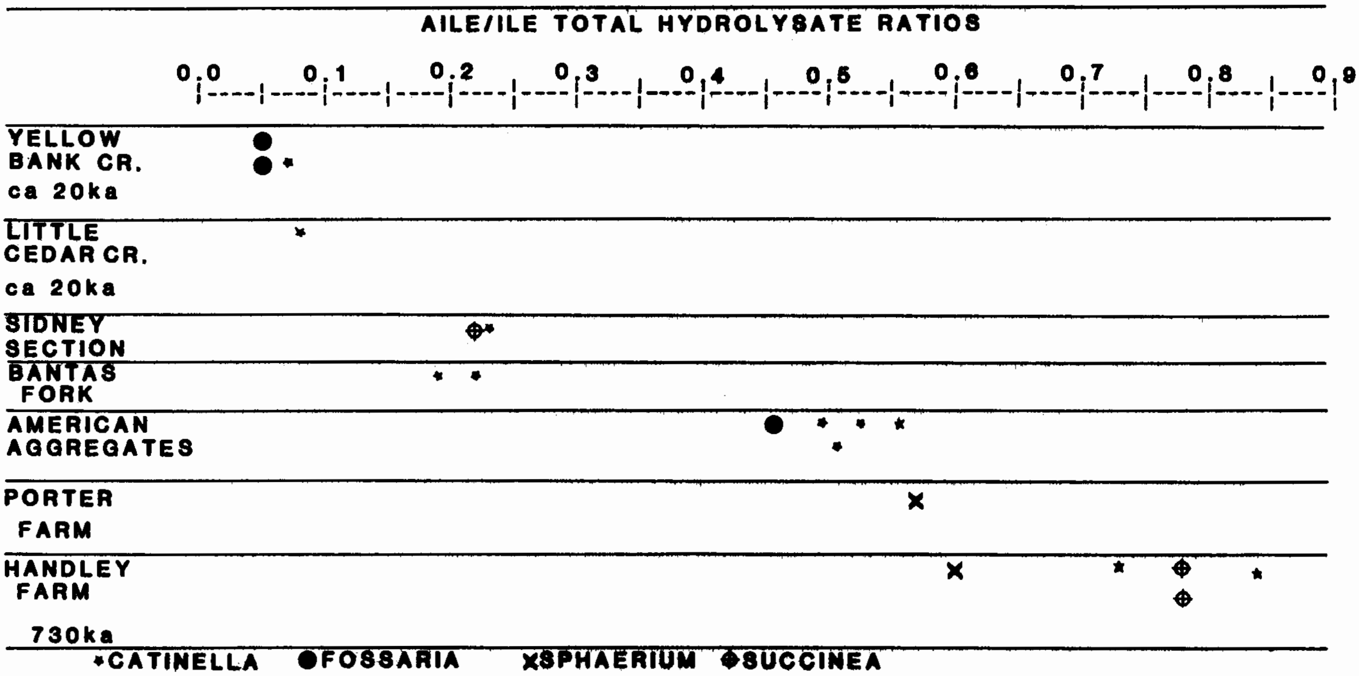


FIGURE 2.—Plot of alle/Ile ratios from samples in study area (see table 2).

## SOIL TERMINOLOGY

Throughout this report, soil descriptions generally follow terminology adopted by the Illinois State Geological Survey (Follmer and others, 1979, Appendix 3) and apply to the sand and smaller size fraction. Particle-size boundaries are: sand, 2.0-0.063 mm; silt, 0.063-0.002 mm; and clay, less than 0.002 mm. In the text, the term "till" is used in a stratigraphic sense. However, this term is not used in the profile descriptions; rather, the lithologic term "diamicton" is used. Soil colors have been determined on moist samples unless noted otherwise.

## ACKNOWLEDGMENTS

Hall and Hernly wish to thank their fellow Sangamon Sweathogs (also known as the Paleosol Posse) for many long hours slinging the dirt at the field-trip stops and other localities of our project. All of them also have made many contributions toward our current ideas and interpretations. They are Bob Barr, Steve Carmer, Paul Haussecker, Camie Jensen, Tony Lopez, Randy Maier, Mudge Morris, Norm Stephens, and Lee Ann Zobbe. Leon Follmer, Ned Bleuer, and Margaret Berry have visited some of field sites and made helpful suggestions. The amino acid analyses were supported by National Geographic Society Grant 8518230.

## Stop 1: AMERICAN AGGREGATES PIT

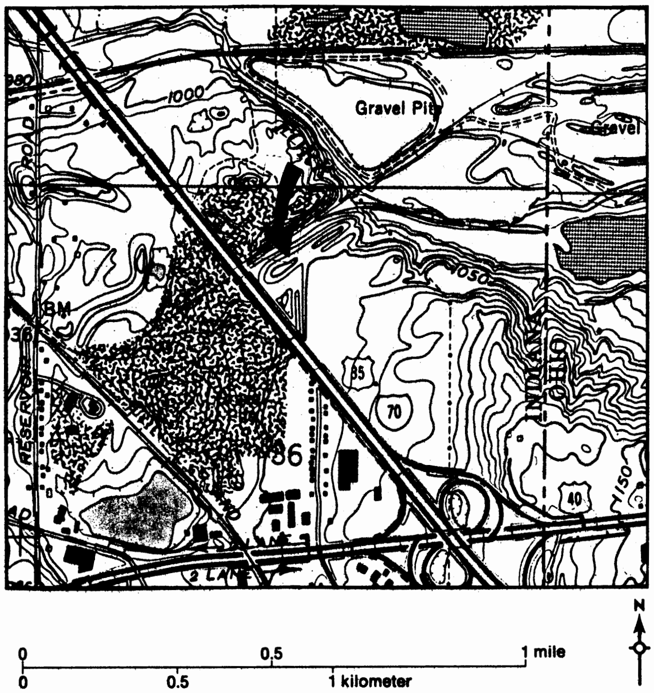


FIGURE 3.—Location of exposures at the American Aggregates pit (Stop 1), New Paris quadrangle, sec. 36, Wayne Township, Wayne County, Indiana.

This stop is a cut for a long-abandoned railroad spur at the American Aggregates pit in Richmond, Indiana (fig. 3). This cut is of major significance to this field trip because it is the type section of both the Whitewater Till and the New Paris sediments (Gooding, 1963). Gooding assigned an early Wisconsinan age to the Whitewater Till and considered the New Paris sediments to represent the first interstade of the Wisconsinan, followed by deposition of the Fayette Till. At the time of his initial work, Gooding assigned a middle Wisconsinan age to the Fayette Till (type section at Sefton Farm, Stop 5), although it was later reassigned to the late Wisconsinan when three underlying tills at the New Paris and other sections were assigned to the middle Wisconsinan (Gooding, 1975). At the north end of the railroad cut, Gooding's Whitewater Till overlies another till with oxidized joints that he interpreted as a deeply truncated Sangamon weathering profile. On that basis, an Illinoian age was assigned to the lower till and it was called the Richmond Till (type section at Wildman Farm). Guccione (1972) also studied the railroad cut. Her stratigraphic interpretation followed Gooding's.

Gooding obtained radiocarbon ages of >33,000 years B.P. and >40,500 years B.P. from the New Paris sediments. Miller and others (1992) obtained a radiocarbon age of >50,000 years B.P. from the same deposits.

Today, most of the railroad cut is badly slumped and parts are vegetated. The Whitewater Till cannot be traced throughout the section. Of necessity, we worked in two separated profiles near opposite ends of the east side of the cut (fig. 4). Profile AA-1 near the north end apparently includes the Whitewater Till and the underlying till (Richmond?) that, in places, contains oxidized joints. Reddish inclusions, supposedly a characteristic of the Whitewater Till according to Gooding, have not been found in this profile. Profile AA-2 near the south end includes the Whitewater Till, the New Paris sediments, and the overlying till (Fayette?). In this profile the Whitewater Till includes dark-red (2.5YR3.5/4) material near the top. Figures 5 and 6 summarize laboratory properties of the two profiles.

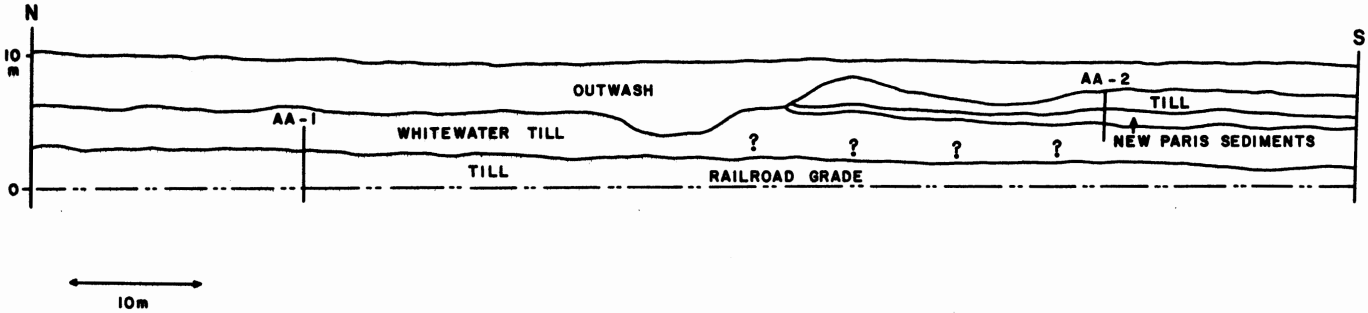


FIGURE 4.—Location of profiles AA-1 and AA-2 at the American Aggregates pit. Correlations are those suggested by Gooding (1963). Amino acid data from New Paris sediments here suggest they and underlying units are Illinoian or older.

## PROFILE DESCRIPTION AND LABORATORY DATA: AA-1
(see also fig. 5)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| WHITEWATER(?) TILL (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| - | | 40+ | **Diamicton**; yellowish brown (10YR5/4); abundant fine mottles, strong brown (7.5YR5/6); silt loam; firm; strongly calcareous; massive, rough; discontinuously weakly cemented with iron oxide; apedal, massive |
| - | | 165 [205]* | **Diamicton**; gray (10YR5/1); silt loam (upper part) to loam and sandy loam (lower part); friable; strongly calcareous; massive, rough |
| UNNAMED TILL (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| Cb? | 0-177 | 177 | **Diamicton**; yellowish brown (10YR5/4); stained with iron oxide (strong brown, 7.5YR5/6); loam; firm; strongly calcareous; massive, rough; apedal, massive |
| Db | 177-270 | 93 | **Diamicton**; dark grayish brown (10YR4/2); loam; firm; strongly calcareous; massive, rough |
| - | 270-276 | 6 | **Silt**; light brownish gray (10YR6/2); silt loam; friable; strongly calcareous; massive, smooth; <1% >2 mm |

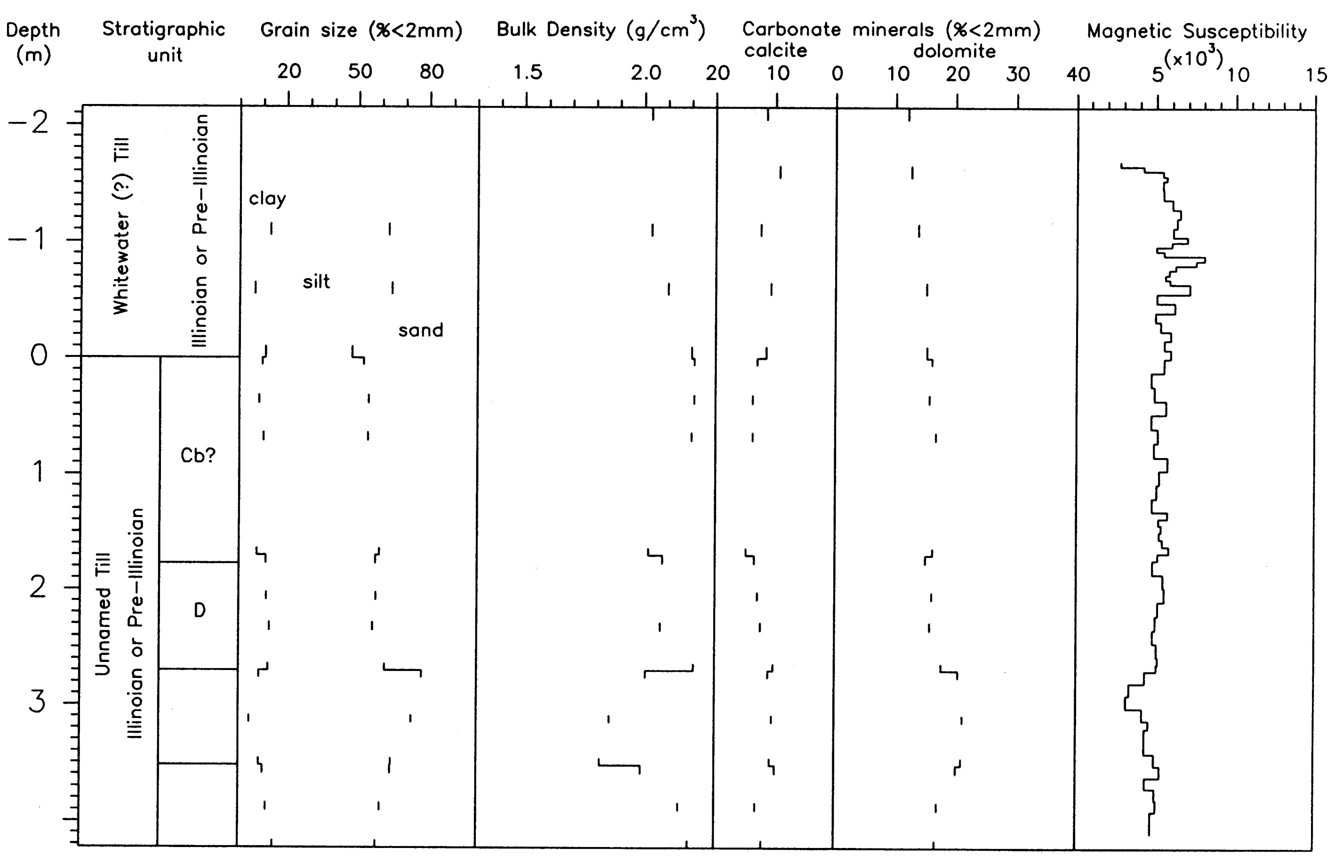


FIGURE 5.—Laboratory data for profile AA-1.

| | | | |
|---|---|---|---|
| - | 276-319 | 43 | **Silt**; grayish brown (10YR5/2); abundant fine mottles, yellowish brown (10YR5/8); silt loam; friable; strongly calcareous; massive, smooth; <1% >2 mm |
| - | 319-390+ | 71+ | **Diamicton**; grayish brown (10YR5/2); silt loam (upper part) to loam (lower part); firm; strongly calcareous; massive, rough |

*[ ] = total described thickness for the unit

## PROFILE DESCRIPTION AND LABORATORY DATA: AA-2
(see also fig. 6)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED SEDIMENTS (LATE WISCONSINAN?) | | | |
| D | | 20+ | **Gravel and sand**; yellowish brown (10YR5/6); matrix sand; loose; noncalcareous; massive, rough to faintly layered; very poorly sorted, angular to rounded; abrupt, irregular lower boundary |
| UNNAMED TILL (LATE WISCONSINAN?) | | | |
| - | 0-25 | 25 | **Diamicton**; yellowish brown (10YR5/4); loam; firm; very strongly calcareous; massive, rough; abrupt, smooth lower boundary |
| - | 25-97 | 72 [97] | **Diamicton**; dark grayish brown (2.5Y4/2); silt loam to loam; firm; strongly calcareous; massive, rough; sparse wood fragments; abrupt, wavy lower boundary |
| NEW PARIS SEDIMENTS (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| - | 97-116 | 69 | **Silt and sand**; gray (10YR5/1) in upper part, pale brown (10YR6/3) in lower part; silt loam (upper part), loam to sandy loam (lower part); friable; slightly to strongly calcareous; massive, smooth; 0% >2 mm; sparse to common disseminated organics, sparse snails; clear lower boundary |
| - | 116-208 | 42 [111] | **Sand**; dark yellowish brown (10YR4/6); stained brown (7.5YR5/4); sandy loam; friable; strongly calcareous; laminated and cross-laminated; 0% >2 mm, moderately sorted, angular; abrupt, smooth lower boundary |
| WHITEWATER TILL (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| - | 208-225 | 17 | **Diamicton**; dark gray (10YR4/1); silt loam; firm; slightly calcareous; massive, rough; clear lower boundary |
| - | 225-239 | 14 [31] | **Diamicton**; dark red (2.5YR3.5/4), dark gray (10YR4/1), and dark yellowish brown (10YR4/4); loam; firm; strongly calcareous; massive, rough; abrupt, wavy lower boundary |
| - | 239-328+ | 89+ [120] | **Diamicton**; gray (10YR5/1); silt loam; firm; weakly calcareous; massive, rough; lower boundary not reached |

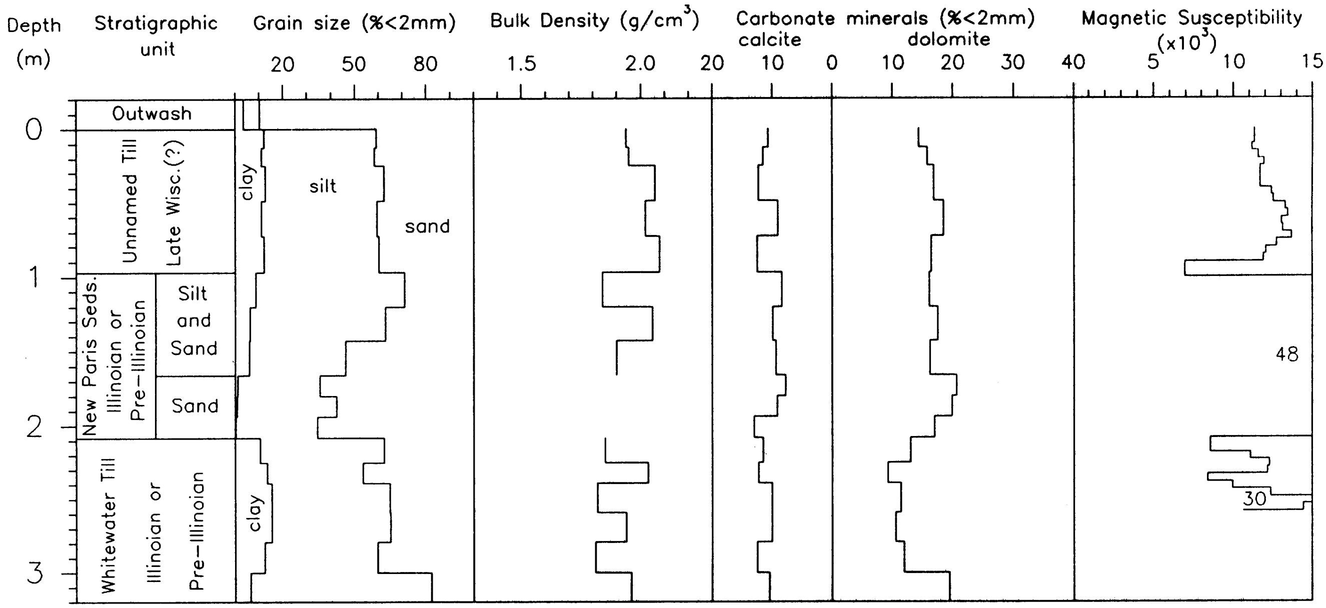


FIGURE 6.—Laboratory data for profile AA-2. The dissimilarity of "Whitewater" Till in figures 5 and 6 in bulk density, calcite-dolomite ratio, and magnetic susceptibility suggests they are different tills.

## DISCUSSION

In profile AA-1, the two tills are closely similar in properties such as bulk density, grain size, magnetic susceptibility, and the calcite/dolomite ratio. If not for the yellowish-brown color (10YR5/4) reflecting oxidation in the upper 177 cm of the lower till, and the occasional oxidized joint, one till might be recognized instead of two. In profile AA-2, the tills above and below the New Paris sediments are similar in bulk density, grain size, and magnetic susceptibility, but the Whitewater Till has a higher calcite/dolomite ratio than the younger till. In comparing the Whitewater Till in profile AA-2 with its alleged counterpart in profile AA-1, we note that the Whitewater Till of AA-2 has a lower bulk density, is finer grained, and has a much higher magnetic susceptibility. These differences, plus the lack of red streaks or inclusions in profile AA-1, suggest that the tills designated "Whitewater" at opposite ends of the railroad cut are, in fact, different tills.

As noted in the introduction to this guidebook, amino acid data suggest that the New Paris sediments and any underlying tills are pre-Wisconsinan. We have quite tentatively correlated the Whitewater Till at AA-2 with an Illinoian till at New Paris (see Discussion for Stop 2, New Paris).

## Stop 2: NEW PARIS

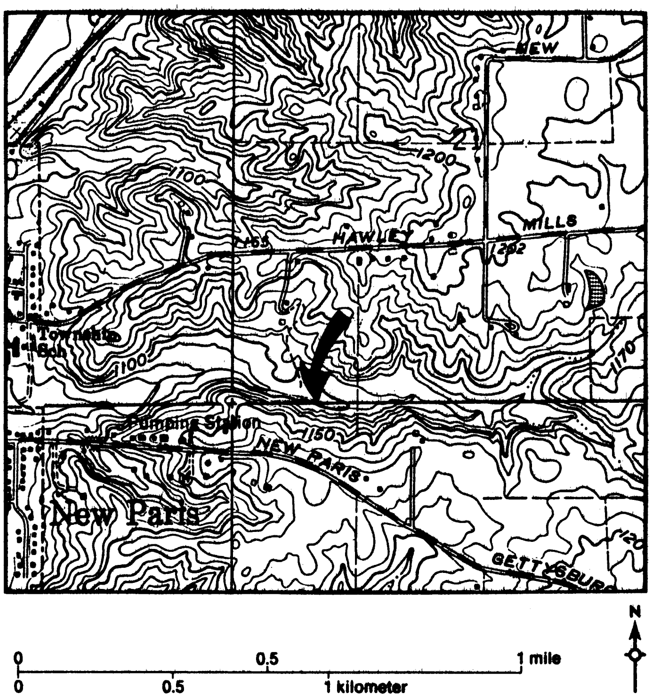


FIGURE 7.—Location of New Paris stream cut (Stop 2), New Paris quadrangle, secs. 21 and 28, Jefferson Township, Preble County, Ohio.

This stop is a cut along an unnamed tributary of the Whitewater River just east of New Paris, Ohio (fig. 7). Although now badly slumped and difficult to study, the cut is important to this field trip because (1) Gooding (1975) interpreted a paleosol within the section as the late middle Wisconsinan Sidney Geosol (formed during Gooding's second Wisconsinan interstade) and believed that the paleosol was underlain by three middle Wisconsinan tills; and (2) below the New Paris "main cut" and extending downstream is a second paleosol, thus the lowest till (or tills) of the "main cut" is (are) bracketed by paleosols. Gooding obtained radiocarbon ages of 23,450±500 and 23,300±500 years B.P. from organic materials at or near the top of the "Sidney Geosol" (labeled "top paleosol" in fig. 8).

Franzi (1980) and Goldthwait and others (1981) interpreted this section to include only one middle Wisconsinan till, which they called the Fairhaven (type section at Four Mile Creek section; labeled "Illinoian till" in fig. 8). Underlying the "Fairhaven Till" are deposits interpreted by these authors as the New Paris sediments and the Whitewater Till (labeled "silt" and "till," respectively in fig. 8). Overlying the "Fairhaven Till" are deposits interpreted by previous workers as Sidney interstadial sediments, the Fayette Till, and younger late Wisconsinan tills.

We have studied the New Paris "main cut" primarily in three profiles (fig. 8). Our attention has been focused mainly on the upper paleosol and the underlying units. In profile NP-1 near the west end of the cut the paleosol is truncated within the B horizon. The profile is developed in a variety of parent materials, including stratified sediments (clay to gravel), a diamicton that is probably colluvium, and till. Other than truncation, the paleosol in this profile was little disturbed by the overriding glacier. Till beneath the paleosol is interrupted by a silt. The stratigraphy of profile NP-1 physically matches that of Goldthwait and others (1981). Fifteen meters west of NP-1 a second, lower paleosol lies at stream level; this paleosol was not seen by earlier workers.

Profile NP-2 near the center of the main cut includes the paleosol and extends into the overlying and underlying tills. This profile is less complicated than NP-1 in terms of parent materials, but the upper horizons, including the organic silt dated by Gooding, are mixed by shearing by the overriding glacier. Profile NP-3 near the east end of the cut also shows evidence of this deformation.

Profile NP-6 is a low stream cut about 100 m downstream (west) from the "main cut." It exposes about 1 m of the older paleosol that can also be found at stream level 15 m downstream from the "main cut." Profile NP-6 was extended to 2 m by augering. This paleosol is developed in till.

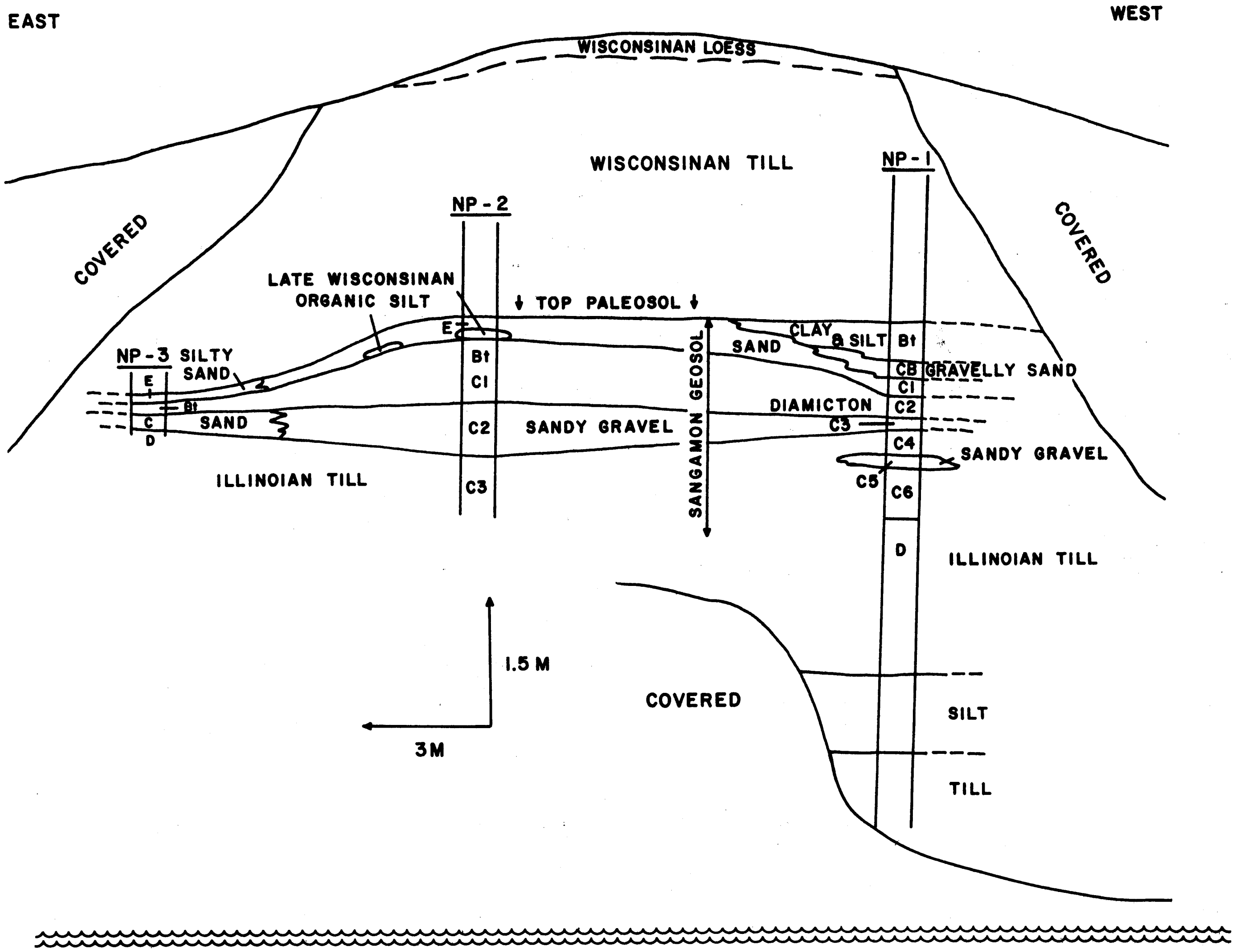


FIGURE 8.—Location of profiles at the New Paris main cut; a second, lower paleosol, not shown on this figure, is at stream level about 15 m west of NP-1. Profile NP-6 is near stream level about 100 m west of NP-1. Gooding (1975) obtained radiocarbon ages of 23,450 and 23,300 years B.P.

## PROFILE DESCRIPTION AND LABORATORY DATA: NP-1
(see also fig. 9)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL (LATE WISCONSINAN) | | | |
| SURFACE SOIL (LOWER PART) | | | |
| C | | 81 | **Diamicton**; yellowish brown (10YR5/4); loam; very firm; strongly calcareous; massive, rough to fissile, blocky; abrupt, irregular lower boundary |
| D | | 89<br>[170] | **Diamicton**; grayish brown (10YR5/2); loam (lower part) to silt loam (upper part); very firm; strongly calcareous; massive, rough to fissile, blocky; abrupt, wavy lower boundary |

UNNAMED SEDIMENTS (ILLINOIAN TO WISCONSINAN)

SANGAMON GEOSOL

| | | | |
|---|---|---|---|
| 2Btb or 2BCb | 0-45 | 45 | **Clay and silt**; yellowish brown (10YR5/8) and light brownish gray (2.5Y6/2); stained with iron oxide (strong brown, 7.5YR5/8) and manganese oxide (very dark gray, N3/0); clay loam and loam; firm; very slightly to slightly calcareous; stratified; 2% >2 mm; weak, fine subangular blocky structure; few thin clay films on ped faces; abrupt, irregular lower boundary |
| 3CBb | 45-64 | 19 | **Gravelly sand**; yellowish brown (10YR5/8); stained dark yellowish brown (10YR4/6); sandy loam; friable; slightly calcareous; massive, rough; 25% >2 mm, very poorly sorted, subrounded to well rounded; apedal, massive; gradual lower boundary |
| 4C1b | 64-84 | 20 | **Sand**; pale brown (10YR6/3); stained yellowish brown (10YR5/8); loamy sand; very friable; slightly calcareous; discontinuously strongly cemented to indurated with iron oxide; massive, smooth; 2% >2 mm, moderately sorted, subrounded; apedal, massive; abrupt, wavy lower boundary |
| 5C2b | 84-109 | 25 | **Diamicton**; yellowish brown (10YR5/8); stained with iron oxide (yellowish red, 5YR5/6); loam; friable to extremely firm; slightly calcareous to noncalcareous; continuously weakly cemented with iron oxide; massive, rough; 5% >2 mm, very poorly sorted, subangular to rounded; apedal, massive; abrupt, wavy lower boundary |
| 6C3b | 109-127 | 18 [127] | **Sandy gravel**; light yellowish brown (10YR6/4); matrix sandy loam to loam; very friable; very slightly calcareous; discontinuously weakly cemented with iron oxide; massive, rough;very poorly sorted, subangular to subrounded; apedal, massive; abrupt, wavy lower boundary |

UNNAMED TILL (ILLINOIAN)

| | | | |
|---|---|---|---|
| 7C4b | 127-154 | 27 | **Diamicton**; brown (10YR5/3); stained dark yellowish brown (10YR4/6) and dark reddish brown (2.5YR3/4); loam; firm; slightly to strongly calcareous; massive, rough; apedal, massive; abrupt, irregular lower boundary |
| 8C5b | 154-168 | 14 | **Gravelly sand**; light yellowish brown (10YR6/4); sandy loam; very friable; strongly calcareous; discontinuously weakly cemented with iron oxide; massive, rough; 10 to 15% >2 mm, very poorly sorted, subangular to subrounded; apedal, massive; clear lower boundary |
| 9C6b | 168-228 | 60 | **Diamicton**; yellowish brown (10YR5/4); stained with iron oxide (strong brown, 7.5YR5/6); loam; firm; strongly calcareous; massive, rough; apedal, massive; abrupt, irregular lower boundary |
| 9Db | 228-333 | 105 | **Diamicton**; dark grayish brown (10YR4/2); loam; slightly to strongly calcareous; massive, rough; apedal, massive; gradual lower boundary |
| - | 333-383 | 50 | **Diamicton**; pale brown to brown (10YR5.5/3); stained with iron oxide in small sand lens and in near-vertical stripes above underlying unit; sandy loam; strongly calcareous; abrupt, wavy lower boundary |
| - | 383-405 | 22 [278] | **Sand and diamicton**; pale brown (10YR6/3); stained with iron oxide (strong brown, 7.5YR5/8); sandy loam; very slightly calcareous; abrupt, wavy lower boundary |

UNNAMED SEDIMENTS (ILLINOIAN)

| | | | |
|---|---|---|---|
| - | 405-496 | 91 | **Silt**; gray (10YR5/1); silt and silt loam; strongly calcareous; fissile, blocky; few thin clay films on block surfaces (stress films?); abrupt, smooth lower boundary |

UNNAMED TILL (ILLINOIAN)

| | | | |
|---|---|---|---|
| - | 496-663+ | 167 | **Diamicton**; gray (10YR5/1); silt loam to loam; slightly calcareous; reddish smears or inclusions near top; lower boundary not reached |

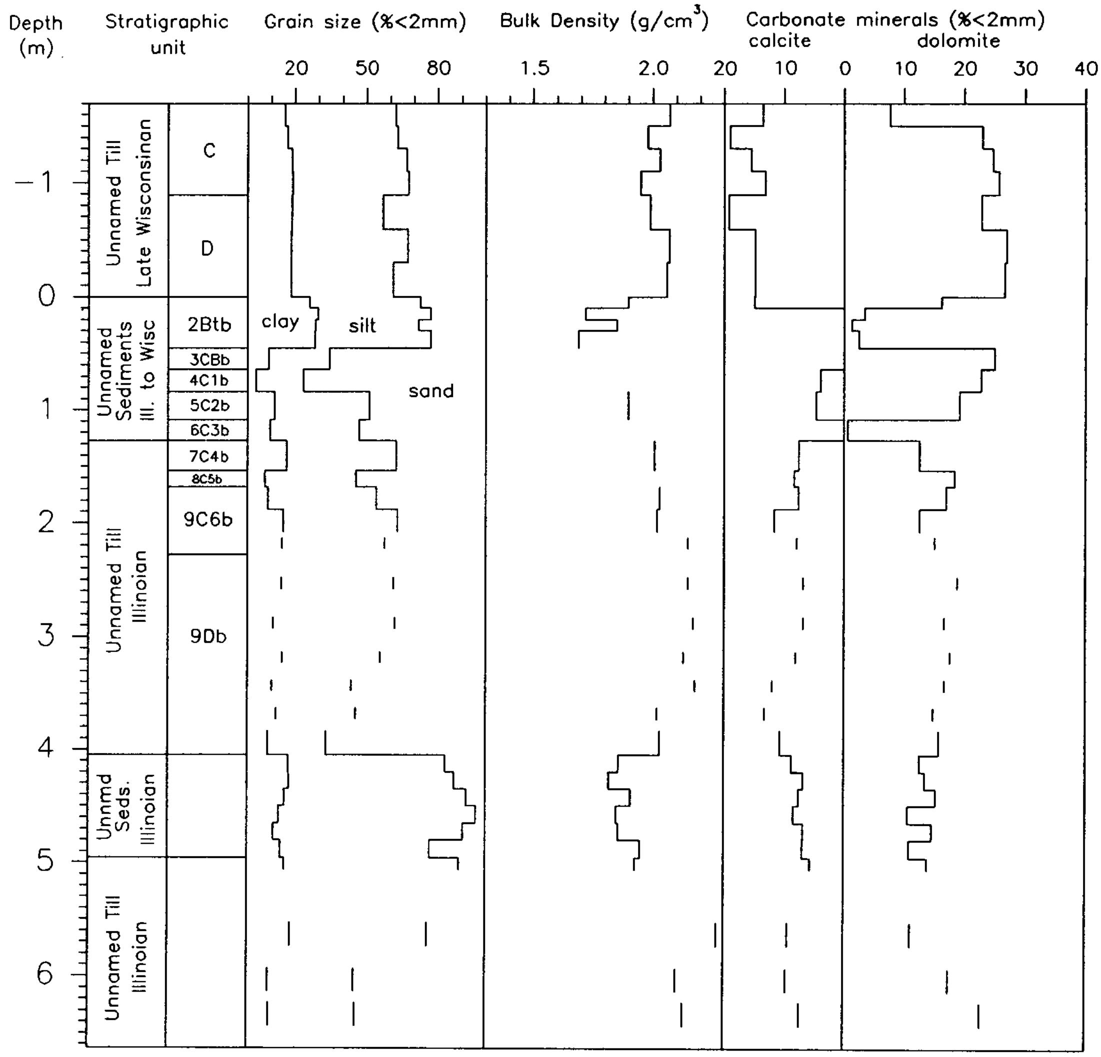


FIGURE 9.—Laboratory data for profile NP-1. Note clay accumulation in Btb horizon and 127 cm carbonate leaching depth. We tentatively correlate the lowest till with the Whitewater Till of profile AA-2 (fig. 6; see Discussion).

## PROFILE DESCRIPTION AND LABORATORY DATA: NP-2
(see also fig. 10)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL (LATE WISCONSINAN) | | | |
| - | | 110 | **Diamicton**; gray (10YR5/1); loam; firm; slightly to strongly calcareous; massive, rough; abrupt, wavy lower boundary |
| UNNAMED SEDIMENTS (ILLINOIAN TO WISCONSINAN) | | | |
| SANGAMON GEOSOL | | | |
| 2E(?)b | 0-15 | 15 | **Silt**; light gray to gray (N6/0); stained brownish yellow (10YR6/6); silt loam; friable; noncalcareous; massive, smooth to fissile, blocky; 5% >2 mm; weak, fine angular blocky structure; abrupt, smooth, broken lower boundary |
| 3Ab | 15-27 | 12 | **Sandy silt**; dark gray (10YR4/1) to very dark gray (10YR3/1); loam; friable; noncalcareous; massive, smooth; apedal, massive; rare to common plant fragments and charcoal; abrupt, irregular, broken lower boundary |

| | | | |
|---|---|---|---|
| 4Btb | 27-85 | 58 | **Diamicton**; yellowish brown (10YR5/6); stained with iron oxide (strong brown, 7.5YR5/6); loam (upper part) to sandy loam (lower part); firm; noncalcareous; discontinuously weakly to strongly cemented with iron oxide; massive, rough; 25% >2 mm, very poorly sorted, subrounded to well rounded; weak, fine angular blocky structure; few thin clay films on ped faces and gravel; abrupt, wavy lower boundary |
| 4C1b | 85-103 | 18 | **Diamicton**; yellowish brown (10YR5/4); stained with iron oxide (strong brown, 7.5YR5/6); sandy loam; firm; strongly calcareous; discontinuously weakly to strongly cemented with iron oxide; massive, rough; 25% >2 mm, very poorly sorted, subrounded to well rounded; apedal, massive; abrupt, irregular lower boundary |
| 5C2b | 103-163 | 60 [163] | **Sandy gravel**; brownish yellow (10YR6/6); stained with iron oxide (strong brown, 7.5YR5/8); matrix loamy sand; loose; noncalcareous; massive, rough; >50% >2 mm, very poorly sorted, angular to subrounded; apedal, single grained; abrupt, wavy lower boundary |

UNNAMED TILL (ILLINOIAN)

| | | | |
|---|---|---|---|
| 6C3b | 163-234+ | 71 | **Diamicton**; yellowish brown (10YR5/6); stained brownish yellow (10YR6/8); silt loam to loam; friable; slightly to strongly calcareous; discontinuously weakly cemented with iron oxide; massive, rough; apedal, massive; lower boundary not reached |

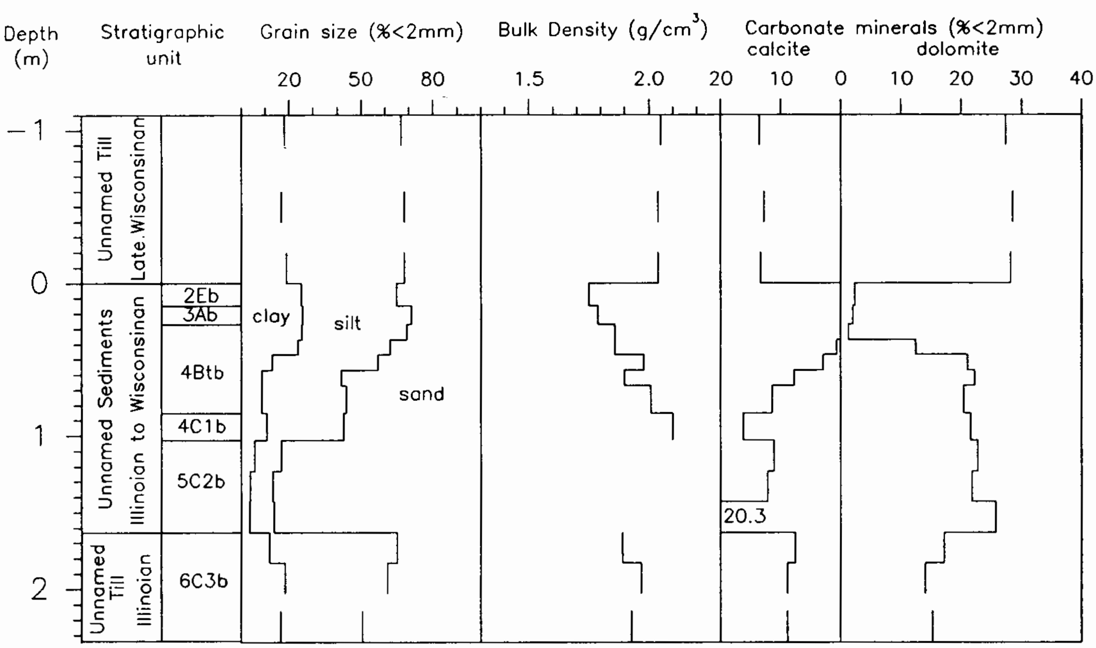


FIGURE 10.—Laboratory data for profile NP-2. Note clay accumulation in Btb horizon and 85 cm carbonate leaching depth.

## PROFILE DESCRIPTION AND LABORATORY DATA: NP-3
(see also fig. 11)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL (LATE WISCONSINAN) | | | |
| - | | 30 | **Diamicton**; grayish brown (10YR5/2); loam; firm; strongly calcareous; massive, rough; abrupt, smooth lower boundary |

| | | | |
|---|---|---|---|
| UNNAMED SEDIMENTS (ILLINOIAN TO WISCONSINAN) | | | |
| SANGAMON GEOSOL | | | |
| 2E(?)b | 0-12 | 12 | **Silty sand**; dark yellowish brown (10YR4/6); clay loam to loam; firm; noncalcareous; massive, smooth; 10% >2 mm, very poorly sorted, angular to rounded; apedal, massive; abrupt, wavy lower boundary |
| 3Btgb | 12-28 | 14 | **Diamicton**; pale brown (10YR6/3); stained with iron oxide (yellowish red, 5YR5/8); clay loam; firm; very slightly calcareous; discontinuously weakly to strongly cemented with iron oxide; massive, rough; 0 to 30% >2 mm, very poorly sorted, subangular to subrounded; weak, fine subangular blocky soil structure; few thin clay films on ped faces and gravel; abrupt, irregular lower boundary |
| 4Cb | 28-45 | 17 [43] | **Sand**; grayish brown (10YR5/2); sandy loam; very friable; noncalcareous; massive, smooth; 5% >2 mm, well sorted, subangular; apedal, massive; abrupt, wavy lower boundary |
| UNNAMED TILL (ILLINOIAN) | | | |
| 5Db | 45-50+ | 5 | **Diamicton**; grayish brown (10YR5/2); loam; friable; slightly calcareous; massive, rough; lower boundary not reached |

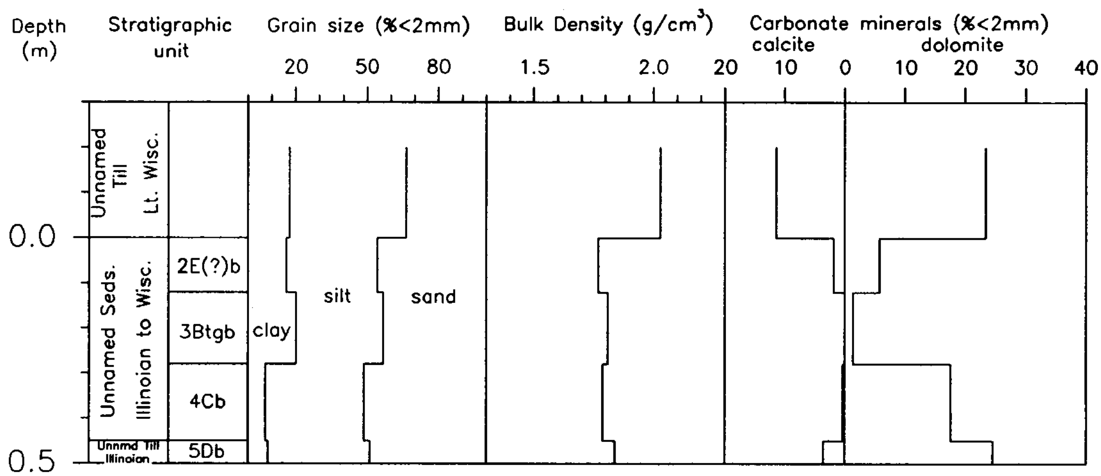


FIGURE 11.—Laboratory data for profile NP-3.

## PROFILE DESCRIPTION AND LABORATORY DATA: NP-6
(see also fig. 12)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL (PRE-ILLINOIAN) | | | |
| YARMOUTH GEOSOL | | | |
| Btb | 0-121 | 121 | **Diamicton**; strong brown (7.5YR5/8), stained yellowish red (5YR5/8) with iron oxide; clay loam; firm; slightly calcareous; massive, rough to fissile, blocky; moderate to strong, fine angular blocky structure; many moderately thick clay films on ped faces. Contains infills of sand (krotovinas), yellowish brown (10YR5/4); friable; slightly calcareous; massive, smooth; <1% >2 mm, well sorted, very angular to subrounded; weak, medium angular blocky structure; few thin clay films on ped faces; abrupt, irregular boundary with the surrounding till |
| Cb | 121-187 | 66 | **Diamicton**; yellowish brown (10YR5/6); loam; strongly calcareous; weak, medium angular blocky soil structure (auger samples) |
| Db | 187-194+ | 7 | **Diamicton**; grayish brown (10YR5/2); loam; strongly calcareous; apedal, massive (auger samples) |

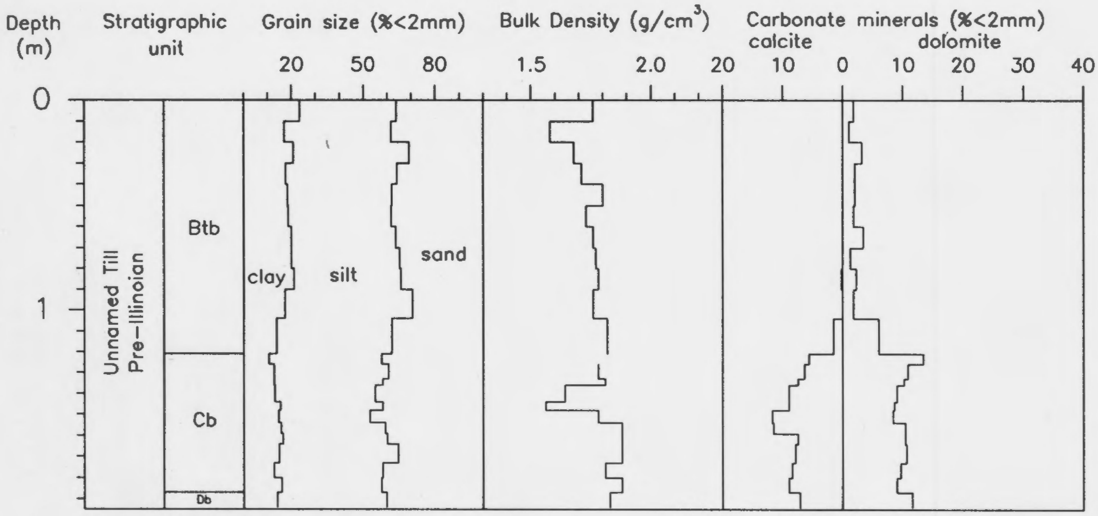


FIGURE 12.—Laboratory data for profile NP-6, Yarmouth Geosol. Note that clay of the Btb horizon is about 15 percent greater than that of the unaltered parent, Db; carbonate leaching depth is at least 121 cm.

## DISCUSSION

The paleosol of the "main cut" is somewhat difficult to interpret both because of truncation at profile NP-1, shearing and mixing of upper horizons at profile NP-2, and numerous changes in parent materials throughout both profiles. However, both profiles include what we have interpreted as a Btb horizon. The horizon is characterized by weak blocky soil structure and thin clay films on ped faces and gravel. Significant clay accumulation in these profiles is indicated by the plots of clay content, especially in profile NP-2, where the parent materials were probably not rich in clay. Most carbonate has been leached to a depth of 127 cm in profile NP-1 but to less than 85 cm in profile NP-2. By most pedogenic criteria, this paleosol is too well developed to have formed during the late middle Wisconsinan, as would be required if the underlying till is also of middle Wisconsinan age. We believe that this paleosol is a truncated and locally butchered Sangamon Geosol.

The older paleosol in profile NP-6 is also truncated. It lies beneath Holocene alluvium. The Btb horizon is characterized by moderate to strong soil structure and moderately thick clay films on ped surfaces. The maximum amount of clay in this horizon is about 15 percent higher than in the till parent material. Most carbonate has been leached to a depth of at least 121 cm. Again, this appears to be a truncated well-developed paleosol. We believe that it is the Yarmouth Geosol.

If our interpretation of the ages of these paleosols is correct, the till (or tills) between is (are) Illinoian. In profile NP-1, the significance of the silt at 405-496 cm is unknown. A comparison of the till above and below this silt shows similar bulk density and calcite/dolomite ratio, but the till below the silt is somewhat finer grained. Red streaks or inclusions were found only in the till below the silt. We tentatively conclude that the silt separates tills of two different Illinoian advances.

We have attempted to correlate the lowest till in profile NP-1 with the Whitewater Till at both AA-1 and AA-2. The NP-1 to AA-1 comparison shows tills with similar bulk densities, but the NP-1 till is finer grained and much lower in calcite/dolomite. The NP-1 to AA-2 comparison is a better match, although the NP-1 till is still much lower in calcite/dolomite. Both the NP-1 and AA-2 tills have red inclusions. We very tentatively suggest a correlation of the oldest Illinoian till at New Paris with the Whitewater Till in AA-2.

## Stop 3: BANTAS FORK

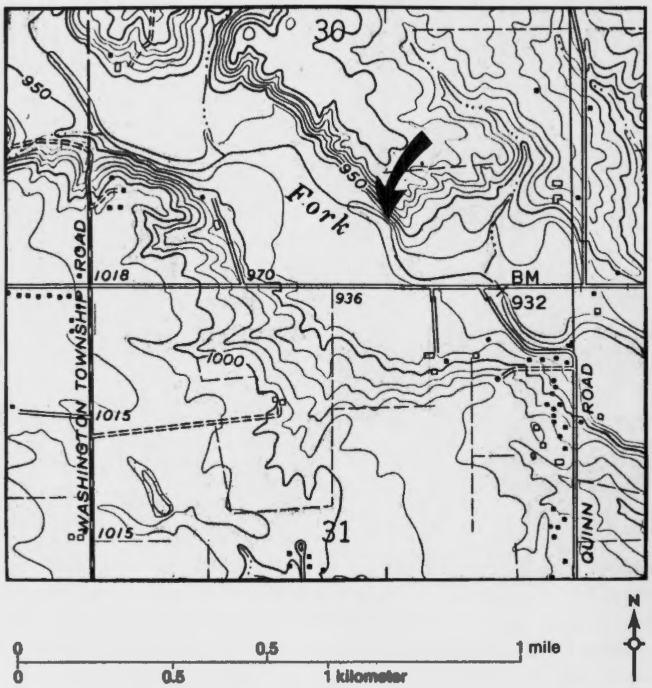


FIGURE 13.—Location of Bantas Fork stream cut (Stop 3), Lewisburg quadrangle, sec. 30, Twin Township, Preble County, Ohio.

This stop is a cut along Bantas Fork about 2 miles (3.2 km) west of New Lexington, in Preble County, Ohio (fig. 13). This exposure is important to the field trip because of (1) a truncated paleosol that has alternately been called the Sangamon Geosol (Guccione, 1972) and the Sidney Geosol (Soller, 1978; Pritchard, 1980; Goldthwait and others, 1981); (2) an organic snail-bearing deposit below the paleosol from which Goldthwait and others (1981) report a radiocarbon age of 44,800±1,700 years B.P.; and (3) evidence for several late Wisconsinan tills.

By Guccione's (1972) interpretation, the Sangamon Geosol is underlain by the Illinoian Richmond Till and overlain by tills whose ages are early (Eaton Till), early to middle (Whitewater Till and/or Fayette Till), and late (Shelbyville, Crawfordsville, and Knightstown Tills) Wisconsinan. By the interpretation of Goldthwait and others (1981), the Sidney Geosol is underlain by the middle Wisconsinan Fairhaven Till and the New Paris sediments and overlain by three late Wisconsinan tills, separated by interstadial or "interphase" sediments.

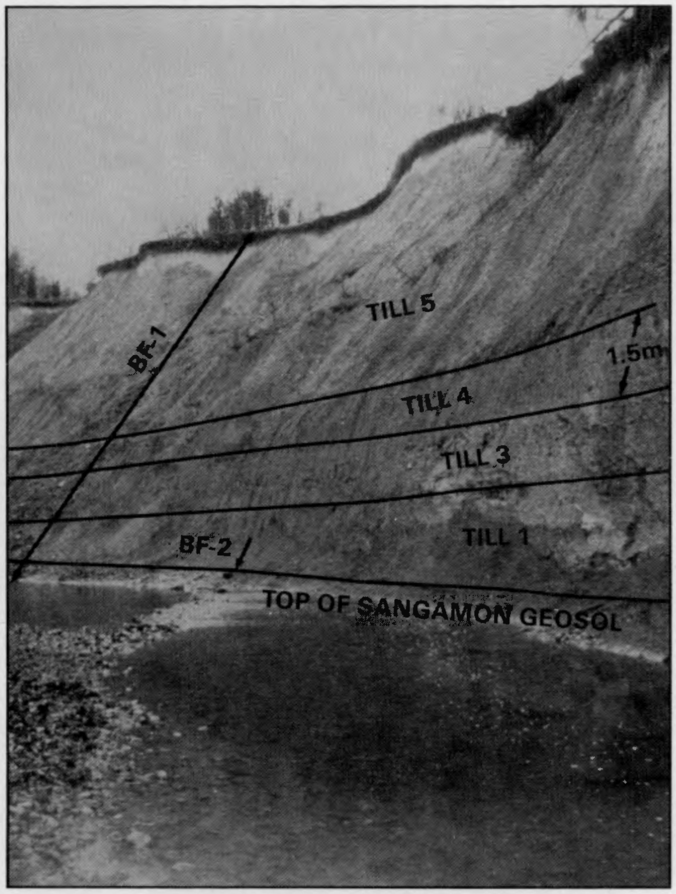


FIGURE 14.—Location of profiles at Bantas Fork. Amino acid data on an organic silt (not shown) below the Sangamon Geosol suggest an Illinoian age for the till in which the paleosol is developed.

We have studied this locality in one long complete profile (BF-1) near the middle of the cut and a short, detailed profile (BF-2) through the paleosol (fig. 14). The paleosol is truncated into the lower B or upper C horizon. The BF-2 profile is developed in diamictons that may or may not be till.

### PROFILE DESCRIPTION AND LABORATORY DATA: BF-1
(see also fig. 15)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| PEORIA LOESS (LATE WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| A | 0-12 | 12 | (not described) |
| Bt | 12-38 | 26 | **Silt**; yellowish brown (10YR5/6, dry); clay loam; very hard; noncalcareous; massive, hackly; 3 to 5% >2 mm; moderate to strong, fine to coarse blocky structure; common thin clay films on ped faces; clear lower boundary |

| | | | |
|---|---|---|---|
| BC | 38-65 | 27 [65] | **Silt**; yellowish brown (10YR5/6, dry); loam; very hard; slightly calcareous; massive, smooth; 3 to 7% >2 mm; weak, coarse blocky structure; few thin clay films on ped faces; clear lower boundary |
| UNNAMED TILL 5A (LATE WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| 2C | 65-343 | 278 | **Diamicton**; very pale brown (10YR7/3, dry); loam; slightly hard; moderately calcareous; massive, rough; apedal, massive; clear, smooth lower boundary |
| 2D | 343-575 | 232 | **Diamicton**; grayish brown (10YR5/2, dry); loam; slightly hard; strongly calcareous; massive, rough; apedal, massive; clear, smooth lower boundary |
| - | 575-591 | 16 [526] | **Diamicton**; yellowish brown (10YR5/4, dry); iron stained (strong brown, 7.5YR5/8, dry); loam; slightly hard; strongly calcareous; massive, rough; very abrupt, smooth lower boundary |
| UNNAMED SEDIMENTS (LATE WISCONSINAN) | | | |
| - | 591-615 | 24 | **Gravel and sand**; light yellowish brown (10YR6/4, dry); matrix loamy sand; loose; strongly calcareous; massive, smooth; moderately to poorly sorted, angular to subangular; abrupt, smooth lower boundary |
| - | 615-648 | 33 | **Silty sand**; light yellowish brown (10YR6/4, dry); sandy loam; loose; strongly calcareous; massive, smooth; 1 to 3% >2 mm, moderately sorted, subangular to subrounded; abrupt, smooth lower boundary |
| - | 648-668 | 20 | **Gravel and sand**; light yellowish brown (10YR6/4, dry); matrix sand; loose; slightly calcareous; massive, rough; moderately to poorly sorted, angular to subangular; abrupt, smooth lower boundary |
| - | 668-690 | 22 | **Gravel and sand**; yellowish brown (10YR5/4, dry); iron stained (strong brown, 7.5YR5/8, dry); matrix loamy sand; loose; slightly to moderately calcareous; massive, rough; large cobbles, poorly sorted, angular to subangular; clear, smooth lower boundary |
| - | 690-725 | 35 | **Diamicton**; yellowish brown (10YR5/4, dry); loam; weakly coherent; slightly to moderately calcareous; massive, rough; 5% >2 mm, moderately to poorly sorted, angular to subangular; clear, smooth lower boundary |
| - | 725-844 | 119 [253] | **Gravel and sand**; yellowish brown (10YR5/4, dry); matrix sandy loam; loose; slightly calcareous; massive, rough; poorly sorted, angular to subangular; clear, smooth lower boundary |
| UNNAMED TILL 5B (LATE WISCONSINAN) | | | |
| - | 844-1253 | 409 | **Diamicton**; dark grayish brown (10YR4/2, dry); silt loam; friable; moderately calcareous; massive, rough; abrupt lower boundary |
| UNNAMED TILL 4 (LATE WISCONSINAN) | | | |
| - | 1253-1401 | 148 | **Diamicton**; yellowish brown (10YR5/4, dry) in upper part, dark grayish brown (10YR4/2, dry) in lower part; silt loam; friable; moderately calcareous; massive, rough to fissile, platy; abrupt lower boundary |
| UNNAMED TILL 3 (LATE WISCONSINAN) | | | |
| - | 1401-1521 | 123 | **Diamicton**; dark grayish brown (10YR4/2, dry); silt loam; high clast content; firm; moderately calcareous; massive, rough; abrupt, smooth lower boundary |
| UNNAMED TILL 2 (LATE WISCONSINAN) | | | |
| - | 1521-1565 | 49 | **Diamicton**; dark grayish brown (10YR4/2, dry); silt loam; very hard; strongly calcareous; massive, rough; gradational lower boundary |
| - | 1565-1570 | 5 [54] | **Silt**; very pale brown (10YR7/3, dry); very firm; strongly calcareous; massive, smooth; 0% >2 mm; abrupt, smooth lower boundary |

UNNAMED TILL 1 (LATE WISCONSINAN)

| | | | |
|---|---|---|---|
| - | 1570-1658 | 88 | **Diamicton**; grayish brown (10YR5/2, dry), dark grayish brown (2.5Y4/2) in lower part; silt loam; firm; strongly calcareous; massive, rough; clear, smooth lower boundary |

SANGAMON GEOSOL (see profile BF-2)

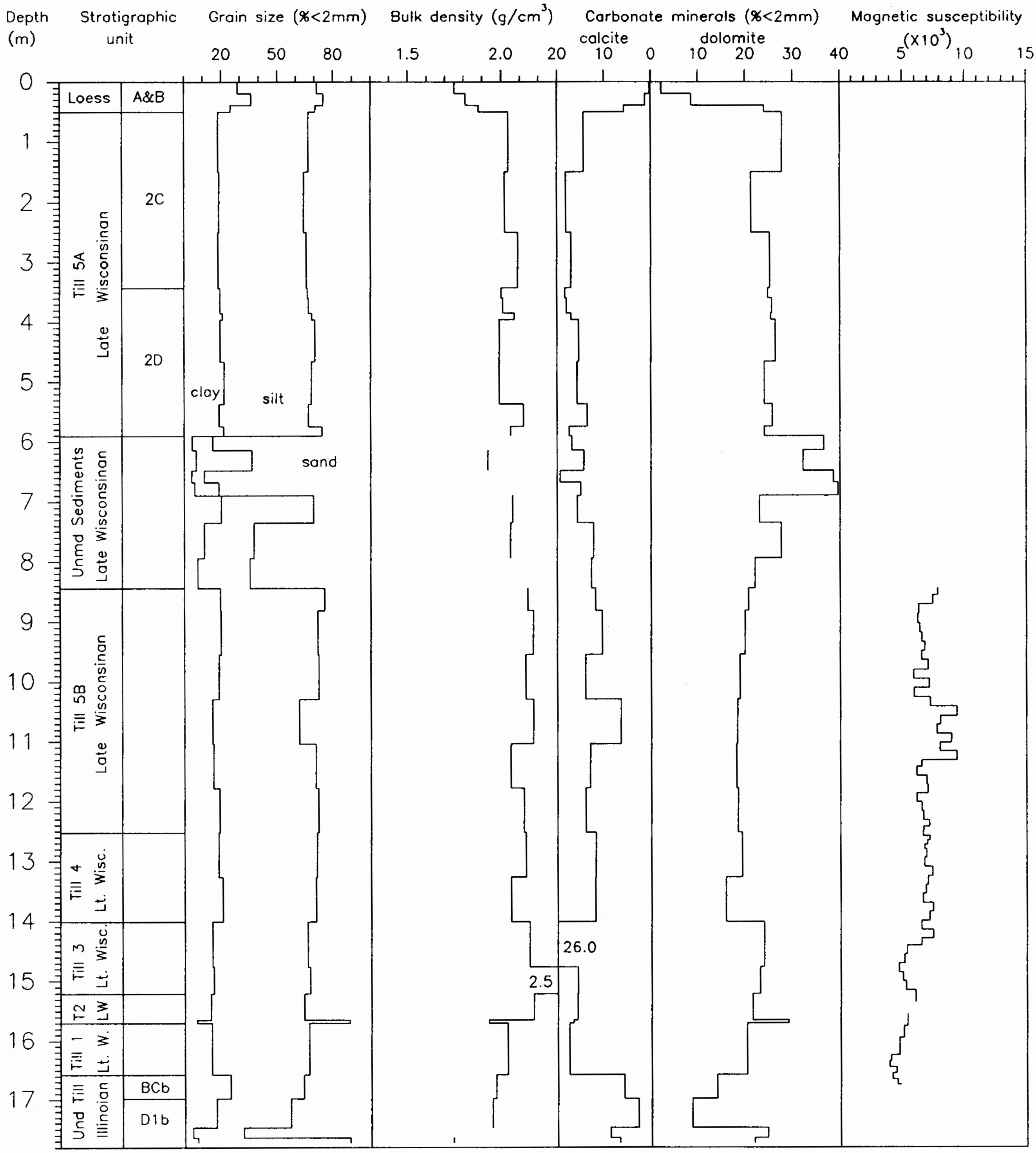


FIGURE 15.—Laboratory data for profile BF-1 (0-1658 cm) and units analyzed more completely in profile BF-2 (below 1658 cm).

## PROFILE DESCRIPTION AND LABORATORY DATA: BF-2
(see also fig. 16)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL 1 (LATE WISCONSINAN) | | | |
| - | | 30 | **Diamicton**; dark grayish brown (2.5Y4/2); silt loam; firm; strongly calcareous; massive, rough; rare wood fragments; abrupt to clear, smooth lower boundary |
| UNNAMED TILL (ILLINOIAN) | | | |
| SANGAMON GEOSOL | | | |
| BCb or CBb | 0-62 (1658-1720) | 62 | **Diamicton**; greenish gray (5GY5/1),yellowish brown (10YR5/8), and gray (5Y5/1); clay loam to loam; firm to very firm; noncalcareous; massive, rough; weak, coarse angular blocky structure; few thin clay films on ped faces and gravel; abrupt, irregular lower boundary |
| Db | 62-99 (1720-1757) | 37 | **Diamicton**; gray (5Y5/1); loam; firm; noncalcareous to slightly calcareous; massive, rough; apedal, massive; clear, wavy lower boundary |
| - | 99-139 (1757-1797) | 40 | **Gravel**; gray (5Y5/1); matrix sandy loam; friable; strongly calcareous; massive, rough; very poorly sorted, very angular to rounded; apedal, massive; abrupt, wavy lower boundary |
| - | 139-150+ (1797-1808+) | 11 | **Sand**; light olive brown (2.5Y5/4); sandy loam; strongly calcareous; massive, smooth to layered; <1% >2 mm, moderately sorted,angular to subrounded; lower boundary not reached |

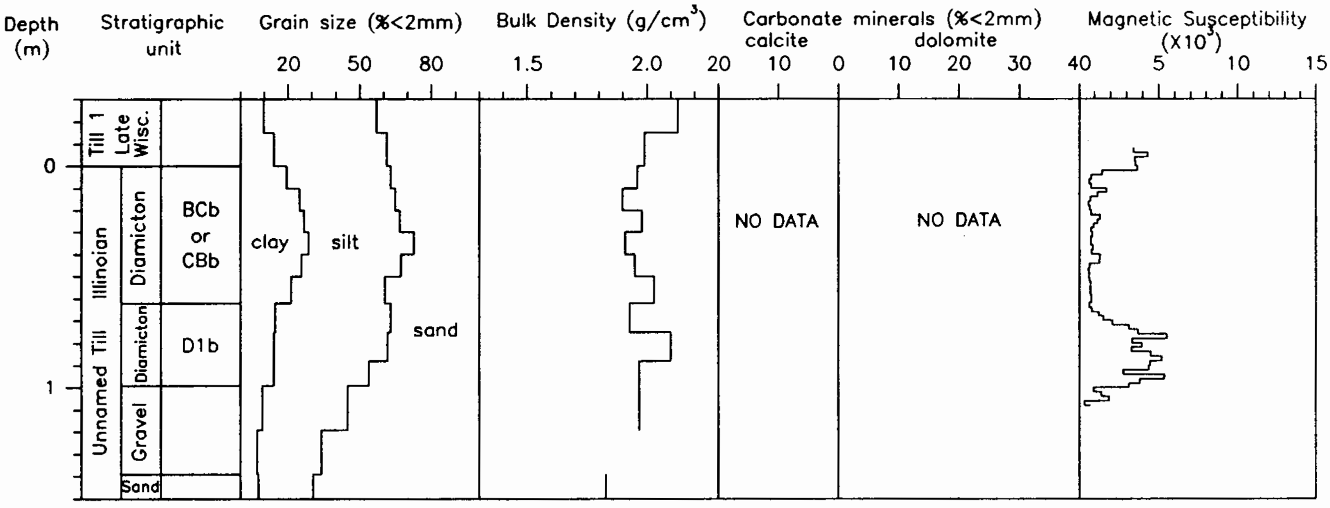


FIGURE 16.—Laboratory data for profile BF-2. The data suggest a truncated Sangamon Geosol; horizon BCb or CBb appears to contain the lower part of a pedogenic clay bulge; unusually, no C horizon exists.

## DISCUSSION

Because the paleosol in this section is truncated deep within its profile, it is difficult to interpret. However, what remains of the BCb or CBb horizon in profile BF-2 displays weak blocky soil structure and a few thin clay films on peds and gravel. The plot of clay (fig. 16) appears to show at least the lower part of a pedogenic clay bulge. The profile is unusual in having no C horizon. However, the pedogenic characteristics seem best interpreted as a truncated Sangamon Geosol. Also, amino acid data from the silt below the paleosol suggest a pre-Wisconsinan age for the diamictons in which the paleosol is developed.

Field evidence suggests as many as five late Wisconsinan tills at this locality. However, a comparison of laboratory data suggests that tills 5 and 4 may be sedimentological phases of the same stratigraphic unit.

## Stop 4: SNYDER FARM

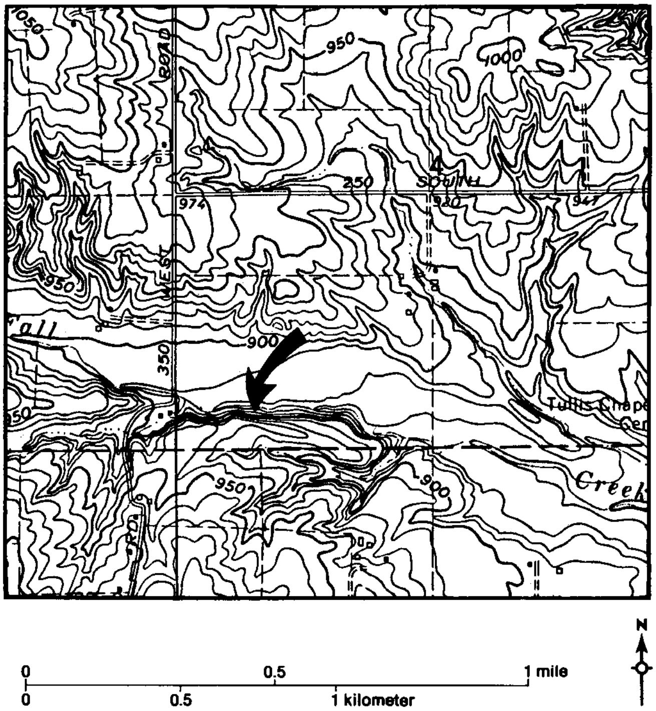


FIGURE 17.—Location of Snyder Farm stream cut (Stop 4), Alpine quadrangle, sec. 4, Connersville Township, Fayette County, Indiana.

This stop consists of two stream cuts along Fall Creek at Snyder Farm, approximately 2.5 miles (4.3 km) northwest of Nulltown, Indiana (fig. 17). The downstream cut is important to this field trip because it contains a mostly intact paleosol overlain by a late Wisconsinan organic silt in turn overlain by an interesting late Wisconsinan sedimentary sequence of outwash, till, lacustrine sediments, and loess. Gooding (1963) interpreted the paleosol as the Sangamon Geosol and the till below the paleosol as the Illinoian Richmond Till. Tills above the paleosols he interpreted as the Fayette Till and the Shelbyville Till.

Gooding obtained a radiocarbon age of 20,400±600 years B.P. (I-1775) from wood in the organic zone on the paleosol. We obtained an age of 19,700±180 years B.P. (ISGS-2164) from wood in the same unit.

We have studied the downstream exposure primarily in a profile (SN-1) near the middle of the cut, with emphasis on the paleosol (fig. 18). The upstream cut was apparently not studied in detail by Gooding (1963). Our section (SN-2) contains two tills separated by a sand and gravel sequence and capped by loess. No paleosol is present.

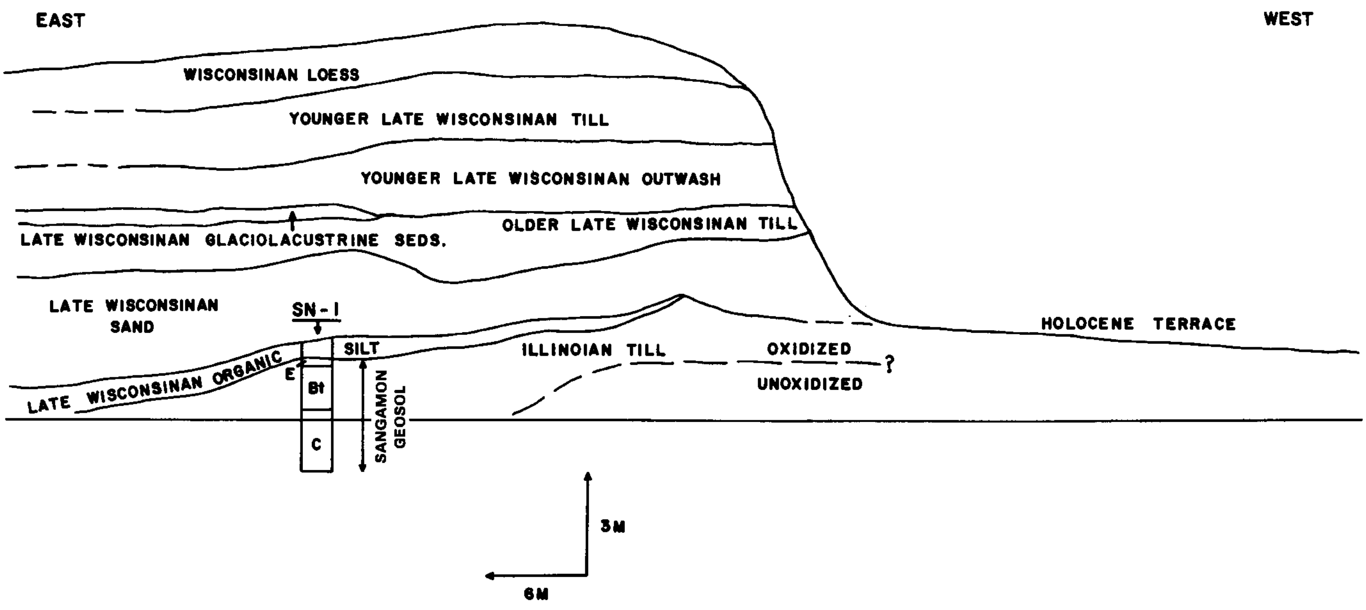


FIGURE 18.—Location of profile SN-1 at Snyder Farm; profile SN-2 is about 300 m west (upstream). This strongly developed Sangamon Geosol formed under moderate drainage conditions prior to truncation and deposition of late Wisconsinan organic silt, which itself developed weak soil structure prior to burial (see Discussion).

PROFILE DESCRIPTION AND LABORATORY DATA: SN-1
(see also fig. 19)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL (LATE WISCONSINAN) | | | |
| - | | 133+ | **Diamicton**; yellowish brown (10YR5/4); loam; friable; strongly calcareous; massive, rough; clear lower boundary |
| UNNAMED SEDIMENTS (LATE WISCONSINAN) | | | |
| - | | 337 | **Sand and gravel**; dark yellowish brown (10YR3/4); matrix loamy sand to sand; loose; strongly calcareous; massive, rough; 50% >2 mm, poorly sorted, subrounded; clear lower boundary |
| - | | 30 [367] | **Silt**; brownish yellow (10YR6/6); silt loam; friable; strongly calcareous; stratified; abrupt lower boundary |
| UNNAMED TILL (LATE WISCONSINAN) | | | |
| - | | 101 | **Diamicton**; yellowish brown (10YR5/6); silt loam to loam; friable; very slightly calcareous; massive, rough; gradual lower boundary |
| UNNAMED SEDIMENTS (LATE WISCONSINAN) | | | |
| - | | 369 | **Sand**; dark yellowish brown (10YR4/6); loamy sand; loose; strongly calcareous; massive, smooth to cross-bedded; 0% >2 mm, well sorted; clear lower boundary |
| UNNAMED SEDIMENTS (LATE WISCONSINAN) | | | |
| SANGAMON GEOSOL | | | |
| Ab | 0-60 | 60 | **Silt**; dark gray (5Y4/1); stained with iron oxide (brown to dark brown, 7.5YR4/4); friable; noncalcareous; massive, smooth to laminated; apedal, massive to "healed" granular structure; abundant plant fragments, common wood and charcoal fragments; abrupt, wavy lower boundary |
| UNNAMED TILL (ILLINOIAN) | | | |
| SANGAMON GEOSOL | | | |
| 2Eb | 60-78 | 18 | **Diamicton**; olive (5Y4/3); uncommon fine mottles, brown to dark brown (7.5YR4/4); stained with iron oxide (brown to dark brown, (7.5YR4/4); manganese concretions (black, N2/0); clay loam to loam; firm; noncalcareous; massive, smooth; weak, very fine angular blocky structure; few moderately thick clay films on gravel; rare charcoal fragments; clear lower boundary |
| 2Bt1b | 78-113 | 35 | **Diamicton**; dark brown (10YR3/3) and dark gray (5Y4/1); abundant coarse mottles, greenish gray (5G5/1) and very dark gray (10YR3/1); clay loam; friable; noncalcareous; massive, rough to fissile, blocky; strong, very fine to fine angular blocky structure; abundant moderately thick clay films on ped faces and on gravel; clear lower boundary |
| 2Bt2b | 113-383+ | 270 | **Diamicton**; yellowish brown (10YR5/6); abundant medium to coarse mottles, grayish brown (10YR5/2); manganese concretions (black, N2/0); clay loam near top and base and loam through middle part; friable; noncalcareous; massive, rough to fissile, blocky; strong, very fine to fine angular blocky structure; abundant moderately thick clay films on ped faces and on gravel; lower boundary not reached |

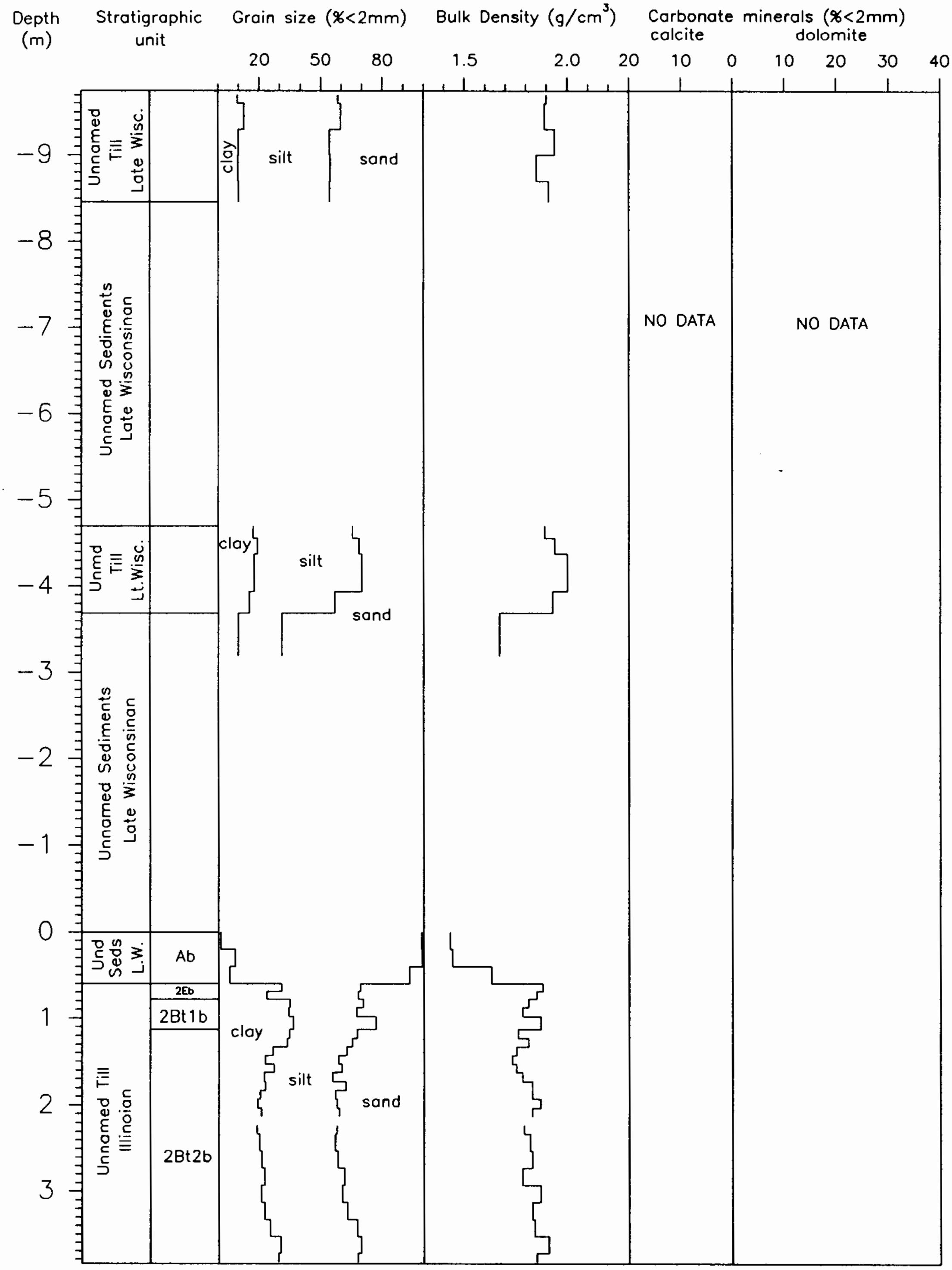


FIGURE 19.—Laboratory data for profile SN-1.

## PROFILE DESCRIPTION AND LABORATORY DATA: SN-2
(see also fig. 20)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| PEORIA LOESS (LATE WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| A | 0-18 | 18 | **Silt**; very dark grayish brown (10YR3/2); silt loam; very friable to friable; noncalcareous; moderate, fine to medium angular blocky structure and moderate, fine granular structure; abrupt, wavy lower boundary |
| EB | 18-31 | 13 | **Silt**; dark yellowish brown (10YR3/4); silt loam; very friable to friable; noncalcareous; weak to moderate, very fine to coarse blocky structure; clear, wavy lower boundary |
| BE | 31-41 | 10 | **Silt**; yellowish brown (10YR5/6); silty clay loam; friable; noncalcareous; moderate, medium to coarse subangular blocky structure; clear, wavy lower boundary |
| Bt1 | 41-102 | 61 [102] | **Silt**; dark brown (7.5YR3/4); common fine mottles, very pale brown (10YR8/3); silty clay loam; firm; noncalcareous; moderate to strong, fine to coarse angular blocky structure; clear, wavy lower boundary |
| UNNAMED TILL (LATE WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| 2Bt2 | 102-132 | 30 | **Diamicton**; yellowish brown (10YR5/4); sandy clay loam; very firm; noncalcareous; strong, medium to coarse angular blocky structure; clear, wavy lower boundary |
| 2BC | 132-151 | 19 | **Diamicton**; dark yellowish brown (10YR4/6); stained with iron oxide (red, 2.5YR4/8); loam; very friable; slightly to moderately calcareous; massive, smooth; clear, smooth lower boundary |
| 2C | 151-292 | 141 [231] | **Diamicton**; dark yellowish brown (10YR4/6); stained with iron oxide (red, 2.5YR4/8); loam; very friable; strongly calcareous; massive, smooth; abrupt, smooth lower boundary |
| UNNAMED SEDIMENTS (LATE WISCONSINAN?) | | | |
| 3D | 292-302 | 10 | **Silt**; yellow (10YR7/6); loose; strongly calcareous; layered; very abrupt, smooth lower boundary |
| - | 302-320 | 18 | **Sandy gravel**; light yellowish brown (10YR6/4); matrix sand; loose; noncalcareous; massive, smooth; poorly sorted, angular to subangular; very abrupt, smooth lower boundary |
| - | 320-351 | 31 | **Sand**; yellowish brown (10YR5/6); loamy sand; loose; noncalcareous; massive, smooth; very well sorted; abrupt, smooth lower boundary |
| - | 351-384 | 33 | **Sandy gravel**; pale brown (10YR6/3); matrix sand; loose; noncalcareous; massive, smooth; poorly sorted, subangular to subrounded; very abrupt, smooth lower boundary |
| - | 384-403 | 19 | **Sand**; yellowish brown (10YR5/6); loamy sand; loose; very slightly calcareous; massive, smooth; very well sorted; abrupt, smooth lower boundary |

| | | | |
|---|---|---|---|
| - | 403-470 | 67 | **Sandy gravel**; yellowish brown (10YR5/4); matrix sand; loose; moderately calcareous; massive, rough; very poorly sorted, angular to rounded; abrupt, smooth lower boundary |
| - | 470-513 | 44 | **Sand**; light olive brown (2.5Y5/4); loose; moderately calcareous; massive, smooth; very well sorted; very abrupt, smooth lower boundary |
| - | 513-521 | 8 | **Sand**; light olive brown (2.5Y5/4); loamy sand; loose; slightly calcareous; massive, smooth; very well sorted; abrupt, smooth lower boundary |
| - | 521-668 | 147 | **Sandy gravel**; olive brown (2.5Y4/4); matrix sand; loose; slightly calcareous; massive, rough; poorly sorted, angular to subangular; abrupt, smooth lower boundary |
| - | 668-677 | 9 | **Sand**; light yellowish brown (10YR6/4); loamy sand; loose; moderately calcareous; massive, smooth; well sorted; abrupt, smooth lower boundary |
| - | 677-734 | 57 | **Sandy gravel**; light olive brown (2.5Y5/4); matrix sand; loose; moderately calcareous; massive, rough; poorly sorted, angular to subangular; abrupt, smooth lower boundary |
| - | 734-833 | 99 | **Silt**; light yellowish brown (10YR6/4); loose; slightly calcareous; massive, smooth; abrupt, smooth lower boundary |
| - | 833-950 | 117 | **Sandy gravel**; yellowish brown (10YR5/4); matrix sand; loose; very slightly calcareous; massive, rough; poorly sorted, angular to subangular; abrupt, smooth lower boundary |
| - | 950-1011 | 61 [720] | **Silt, sand, and gravel**; yellowish brown (10YR5/4); stained with iron oxide (reddish yellow, 7.5YR7/8); matrix silt loam to sandy loam; friable; strongly calcareous; massive, rough; poorly sorted, angular to subangular; clear, smooth lower boundary |
| UNNAMED TILL (LATE WISCONSINAN?) | | | |
| - | 1011-1663 | 652 | **Diamicton**; dark gray (10YR4/1); silt loam to loam; firm; strongly calcareous; rough |

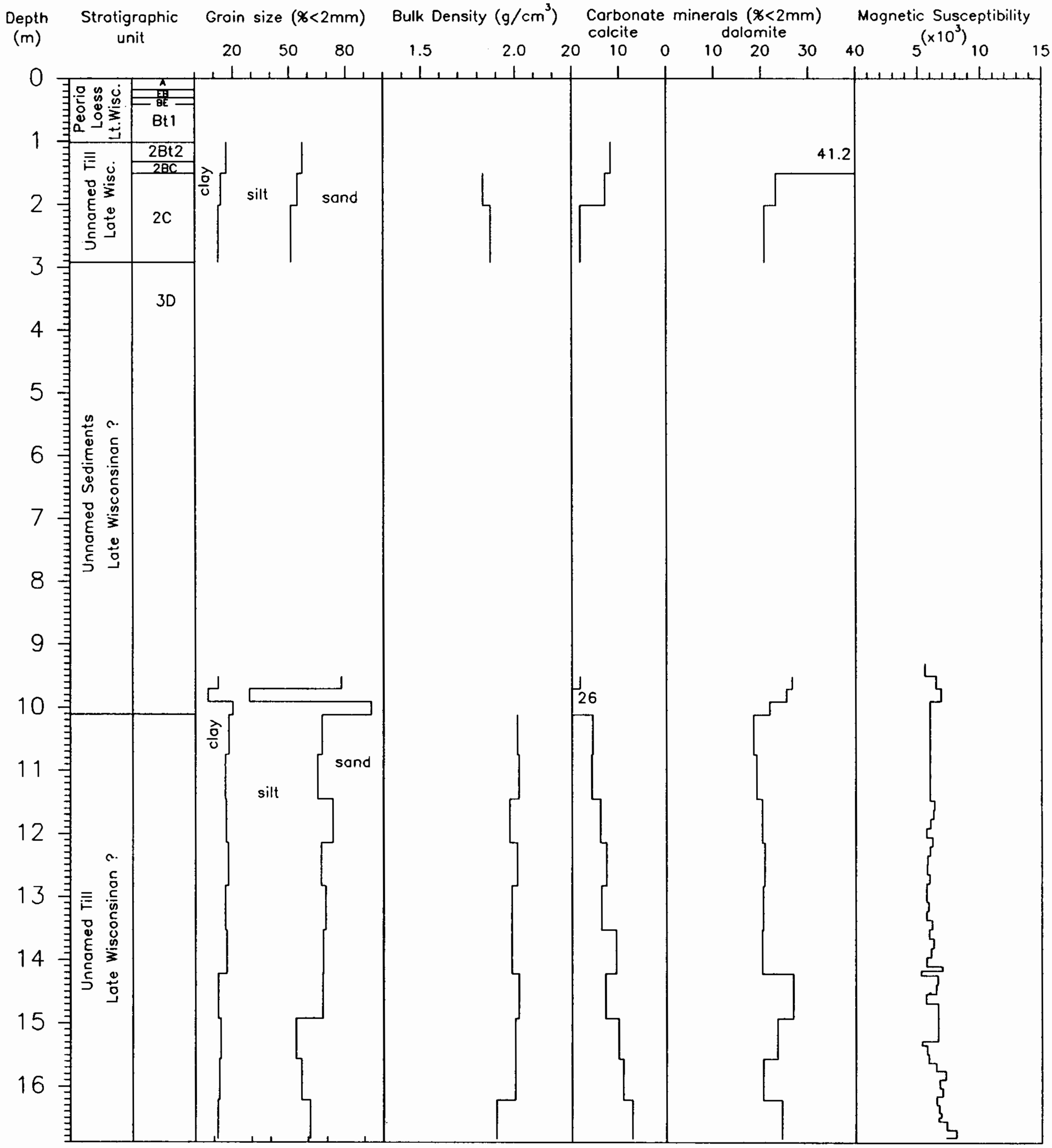


FIGURE 20.—Laboratory data for profile SN-2.

## DISCUSSION

The organic silt in the SN-1 cut occupies the position of the Ab horizon of the Sangamon Geosol. This unit does show some evidence of weak soil development; in places, there is a hint of "healed" granular structure, and carbonates have been leached. However, this organic unit has an abrupt, wavy boundary with the underlying Eb horizon. Furthermore, the radiocarbon ages indicate a late Wisconsinan age. All our evidence suggests truncation of the Sangamon Geosol prior to the late Wisconsinan followed by deposition of silt, probably mostly as loess reworked in shallow ponds, and weak soil development prior to burial by outwash sands deposited during the late Wisconsinan glacial advance.

The rest of the Sangamon Geosol profile has characteristics that indicate a strongly developed soil formed under conditions of moderate drainage. The entire 383 cm of the profile is leached of carbonates. The Btb horizon has strong angular blocky soil structure and moderately thick clay films on ped faces and gravel. The profile has a distinct pedogenic clay bulge, and the maximum amount of clay in the Btb horizon exceeds the minimum amount of clay lower in the profile by about 20 percent. The variety of colors, ranging from yellowish brown (10YR5/6) to greenish gray (5G5/1), suggests that soil development occurred as the water table fluctuated.

The late Wisconsinan sediments above the paleosol at SN-1 are primarily an alternating sequence of waterlaid sediments and tills. The same general sequence seems to characterize the upstream cut (profile SN-2). No paleosol has been found in this cut or by augering below stream level. We believe that the entire paleosol was eroded upstream of the SN-1 cut. The late Wisconsinan sediments are thicker upstream of this point and may have been deposited in a paleovalley.

## Stop 5: SEFTON FARM

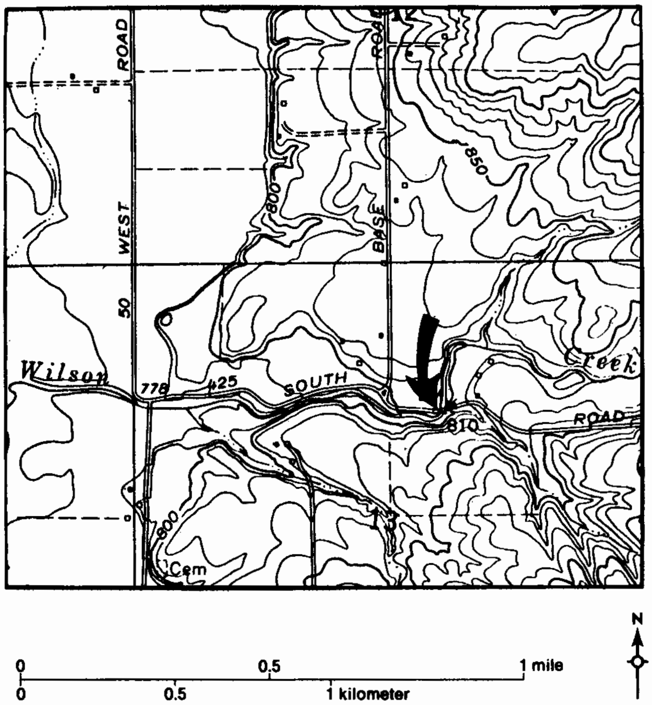


FIGURE 21.—Location of Sefton Farm stream cut (Stop 5), Alpine quadrangle, sec. 13, Jackson Township, Fayette County, Indiana.

This stop is a small stream cut along Wilson Creek at Sefton Farm, about 1 mile (0.6 km) east of Nulltown, Indiana (fig. 21). This cut is of significance to this field trip because (1) it contains a well-developed gleyed paleosol interpreted as the Sangamon Geosol by Gooding (1963), and (2) it is the type section for Gooding's Fayette Till and Connersville sediments. Gooding believed that the Whitewater Till did not extend this far south, thus the Fayette Till directly overlies the Sangamon Geosol. In 1963, Gooding believed that the age of this till was middle Wisconsinan and that the overlying Connersville sediments represented the second Wisconsinan interstadial. By 1975, Gooding was recognizing other tills as middle Wisconsinan and had reassigned the Fayette Till to the early late Wisconsinan. The Connersville interstadial had, in turn, become the third Wisconsinan interstadial, following the New Paris and the Sidney interstadials.

Gooding obtained radiocarbon ages of 21,150±260 years B.P. (I-4345) from wood in the Fayette Till and 20,000±500 years B.P. (I-610) from wood in the Connersville sediments. We dated wood from the Ab horizon of the paleosol at >46,100 years B.P. (ISGS-2163).

We have studied the exposure in two profiles, SE-1 through the paleosol and SE-2 through younger sediments. Profile SE-1 includes the basal part of the Fayette Till. About 1 m of the paleosol is exposed above stream level; the section was extended about 4 m deeper by augering. The heavily gleyed paleosol is believed to be developed in overbank deposits. Profile SE-2 includes the basal part of thick sand and gravel deposits; unnamed late Wisconsinan sediments that include sand, silt, and till; the Connersville sediments; and the Fayette Till.

### PROFILE DESCRIPTION AND LABORATORY DATA: SE-1
(see also fig. 22; this profile is located below and a few meters west of profile SE-2)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| FAYETTE TILL (LATE WISCONSINAN) | | | |
| - | | 35+ | **Diamicton**; grayish brown (10YR5/2), basal 2 cm dark gray (10YR4/1); loam; very slightly to strongly calcareous; massive, rough; abrupt, wavy lower boundary |
| UNNAMED SEDIMENTS (ILLINOIAN TO WISCONSINAN) | | | |
| SANGAMON GEOSOL | | | |
| Ab | 0-9 | 9 | **Silt**; very dark gray (10YR3/1) in top 3 cm, grayish brown (10YR5/2) in lower 6 cm; silty clay loam; very firm; very slightly calcareous; massive, smooth; 1% >2 mm; moderate, fine to medium blocky structure, partially "healed"; many thick clay films on ped faces; rare to abundant wood and plant fragments; abrupt, smooth lower boundary |
| Eb | 9-26 | 17 | **Silt**; olive gray (5Y4/2); abundant fine mottles, yellowish brown (10YR5/6); silty clay loam; firm; noncalcareous; massive, smooth; 1% >2 mm; moderate, very fine to coarse subangular blocky structure, partially "healed"; common moderately thick clay films on ped faces; clear, irregular lower boundary |
| EBgb | 26-70 | 44 | **Silt**; grayish brown (2.5Y5/2); silans light gray to gray (10YR6/1); abundant fine to medium mottles, yellowish brown (10YR5/4) and light gray (10YR7/1); very firm; noncalcareous; massive, hackly; <1% >2 mm; moderate to strong, very fine to coarse subangular blocky structure; continuous thick clay skins on ped faces; abrupt, irregular lower boundary |

| | | | |
|---|---|---|---|
| Bgb | 70-503 | 433 [503] | **Silt**; dark greenish gray (5G4/1); argillans dark greenish gray (5BG4/1); black (N2/0) manganese nodules; common medium to coarse mottles, greenish gray (5GY6/1); silty clay to 196 cm, silty clay loam to 484 cm, silty clay to clay loam to 503 cm; very firm to friable; massive, hackly; 2-5% >2 mm; limestone fragments in basal 8 cm; moderate to strong, fine to coarse subangular blocky structure; common to continuous thick clay films on ped faces; lower boundary believed to be at bedrock |

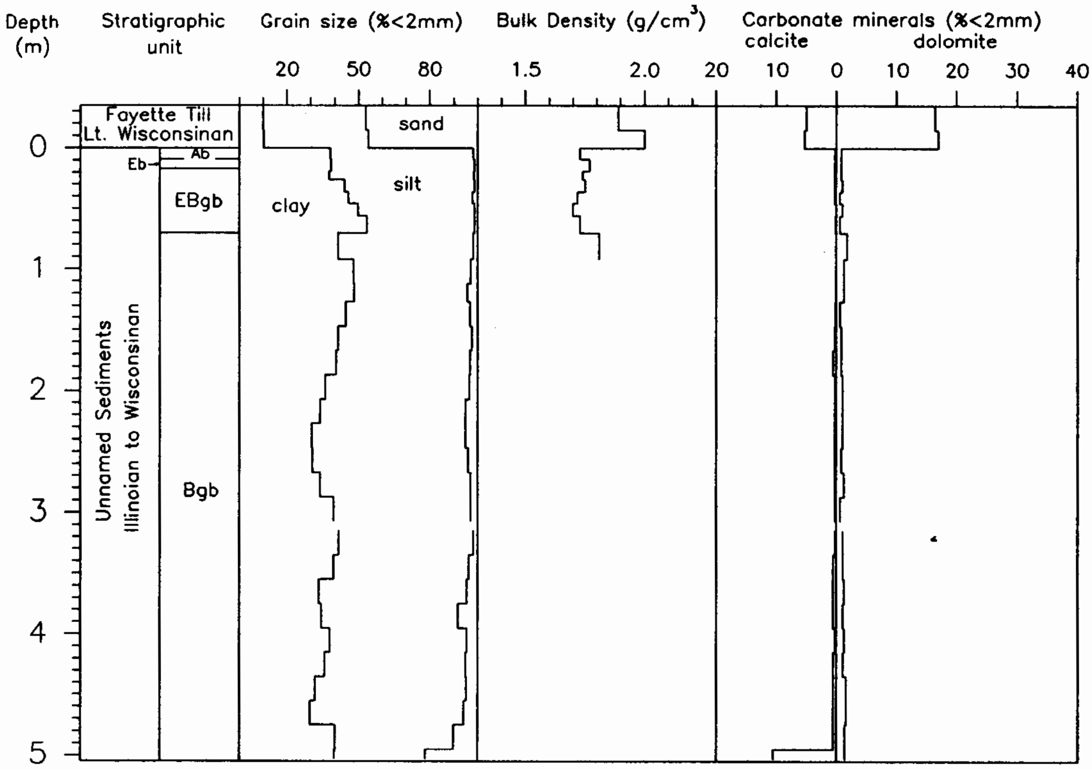


FIGURE 22.—Laboratory data for profile SE-1. The profile developed in fluvial overbank deposits and/or loess under very poorly drained conditions.

## PROFILE DESCRIPTION: SE-2

(this profile does not contain a paleosol and has not been sampled for laboratory analysis; this profile is located above and a few meters east of profile SE-1)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED SEDIMENTS (LATE WISCONSINAN) | | | |
| - | | 20+ | **Sand**; dark yellowish brown (10YR4/4); very slightly calcareous; massive, rough; 30% >2 mm, very poorly sorted, subrounded to rounded; clear, wavy lower boundary |
| - | | 5 | **Silt**; light yellowish brown (10YR6/4) and strong brown (7.5YR4/6); silty clay loam; very slightly calcareous; laminated; abrupt, irregular lower boundary |
| - | | 27 | **Gravelly sand**; yellowish brown (10YR5/6); stained strong brown (7.5YR4/6); very slightly calcareous; massive, rough; 40% >2 mm, very poorly sorted to poorly sorted, subangular to rounded; abrupt, wavy lower boundary |
| - | | 0-10 | **Sandy silt**; very dark grayish brown (2.5Y3/2); sandy clay loam; very slightly calcareous; massive, smooth; charcoal and wood fragments; occurs as a lens about 50 cm long; abrupt, irregular lower boundary |

| | | |
|---|---|---|
| - | 8 | **Silty sand**; yellowish brown (10YR5/4); loamy sand; very slightly calcareous; massive, rough; 0% >2 mm, poorly sorted, angular to subangular; abrupt, wavy lower boundary |
| - | 7 | **Silt**; yellowish brown (10YR5/6); silt loam; very slightly calcareous; massive, smooth; abrupt, wavy lower boundary |
| - | 0-4 [67-81] | **Gravelly sand**; dark yellowish brown (10YR4/6); very slightly calcareous; massive, rough; 35% >2 mm, poorly sorted, angular; abrupt, irregular lower boundary |
| UNNAMED TILL (LATE WISCONSINAN) | | |
| - | 23 | **Diamicton**; dark yellowish brown (10YR4/4); loam; strongly calcareous; massive, rough; clear, wavy lower boundary |
| - | 63 [86] | **Diamicton**; dark grayish brown (2.5Y4/2); loam; strongly calcareous; massive, rough; abrupt, smooth lower boundary |
| CONNERSVILLE SEDIMENTS (LATE WISCONSINAN) | | |
| - | 6 | **Silt**; dark grayish brown (10YR4/2); silt loam; strongly calcareous; massive, smooth; plant fragments; abrupt, wavy lower boundary |
| FAYETTE TILL (LATE WISCONSINAN) | | |
| - | 32+ | **Diamicton**; brown (10YR5/3); loam; strongly calcareous; massive, rough; lower boundary not reached |

## DISCUSSION

The paleosol profile (SE-1) at this locality seems intact. The radiocarbon age of >46,000 years suggests that the A horizon may be the original one for the profile. The B horizon is heavily gleyed and over 4 m thick. It has a moderate to strong soil structure and thick clay films on ped faces. The parent material is not till; it lacks grains >2 mm and has very little sand. Fluctuations with depth in the abundance of different silt fractions may indicate original stratification. We believe that this profile developed in fluvial overbank deposits and/or loess under very poorly drained conditions. The late Wisconsinan units below the sand and gravel are now quite poorly exposed.

## OPTIONAL STOP: PORTER FARM

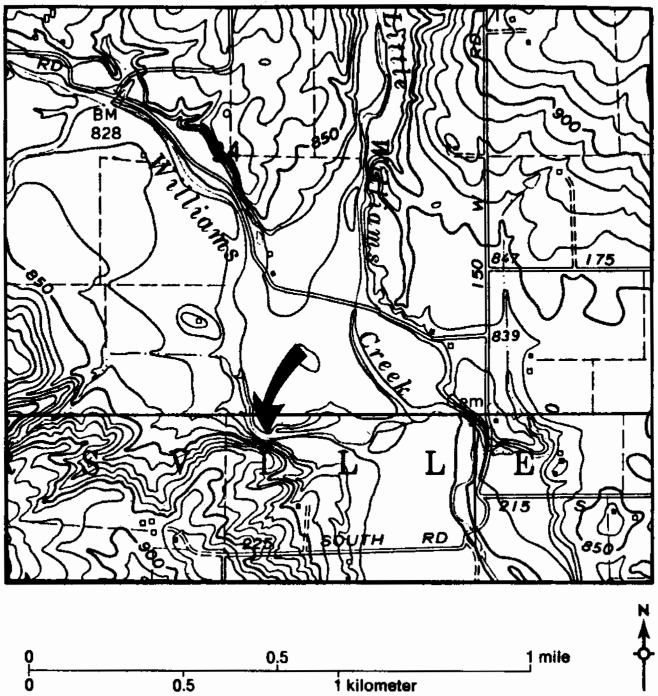


FIGURE 23.—Location of Porter Farm stream cut (optional stop), Alpine quadrangle, sec. 34, Connersville Township, Fayette County, Indiana.

This locality is a stream cut along Williams Creek at Porter Farm, about 2 miles (3.2 km) southwest of Connersville, Indiana (fig. 23). The exposure is important primarily because it contains a basal lacustrine sequence that has reversed polarity. The overlying sequence of till, sand and gravel, and more till does not include a paleosol. Gooding (1963) interpreted the upper till as the early Wisconsinan Whitewater Till, the sand and gravel deposits as Illinoian outwash, and the lower till as the Illinoian Richmond Till.

We have studied this locality (fig. 24) in one long profile (PO-1) and one short profile (PO-4) through the upper till and the sand and gravel and another, shorter profile (PO-2) through the lower till.

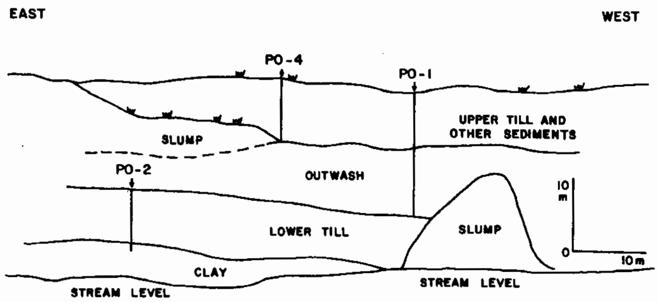


FIGURE 24.—Location of profiles PO-1, PO-2, and PO-4 at Porter Farm. A paleosol is not present; age relations and correlations with units at other stops are uncertain.

### PROFILE DESCRIPTION AND LABORATORY DATA: PO-1
(see also fig. 25)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| PEORIA LOESS (LATE WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| A | 0-25 | 25 | **Sandy silt**; dark brown (10YR3/3) to dark yellowish brown (10YR3/4); loam; friable; noncalcareous; massive, smooth; moderate, medium angular blocky structure and weak, fine to medium platy structure; few thin clay films on ped faces and in pores; abrupt, smooth lower boundary |
| Bt1 | 25-60 | 35 [60] | **Sandy silt**; dark yellowish brown (10YR4/4); uncommon fine mottles, dark yellowish brown (10YR4/6); loam; firm; noncalcareous; massive, smooth to massive, hackly; moderate, fine to medium angular blocky structure; common thin clay films on ped faces; abrupt, smooth lower boundary |
| UNNAMED SEDIMENTS (ILLINOIAN TO WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| 2Bt2 | 60-76 | 16 | **Clay**; dark grayish brown (10YR4/2); common fine mottles, yellowish brown (10YR5/6); very firm; noncalcareous; massive, hackly; strong, fine to medium angular blocky structure; abundant moderately thick clay films on ped faces; clear lower boundary |
| 2Bt3 | 76-100 | 24 | **Clay**; dark grayish brown (10YR4/2); abundant fine to medium mottles, dark yellowish brown (10YR4/6); very firm; noncalcareous; massive, hackly; strong, medium to fine structure; abundant moderately thick clay films on ped faces; clear lower boundary |

| | | | |
|---|---|---|---|
| 2Bt4 | 100-111 | 11 | **Clay**; dark gray (10YR4/1), very dark gray (10YR3/1) on ped faces; common fine to medium mottles, dark yellowish brown (10YR4/6); silty clay; very firm; noncalcareous; massive, hackly; moderate to strong, coarse to medium angular blocky structure; abundant moderately thick clay films on ped faces; abrupt, wavy lower boundary |
| 2BC | 111-120 | 9 | **Clay**; brown (10YR5/3); abundant medium to coarse mottles, pale brown (10YR6/3), and fine to medium mottles, yellowish brown (10YR5/8); clay loam; friable; noncalcareous; massive, smooth; weak, medium subangular blocky structure; few thin clay films on ped faces; abrupt, smooth lower boundary |
| 3C1 | 120-184 | 64 | **Gravelly sand**; brown (10YR5/3); abundant fine to coarse mottles, pale brown (10YR6/3) and yellowish brown (10YR5/8); matrix sandy loam; loose to very friable; slightly to strongly calcareous; discontinuously weakly cemented with iron and manganese oxides; massive, smooth to massive, rough; 5 to 10% >2 mm, moderately to very poorly sorted, angular to rounded; apedal, massive; clear lower boundary |
| 3C2 | 184-244 | 60 | **Gravelly sand and sandy silt**; brown (10YR5/3); common medium mottles, dark yellowish brown (10YR4/6); matrix loamy sand to silt loam; loose; strongly calcareous; discontinuously weakly cemented with iron oxide; massive, rough; 20 to 50% >2 mm, poorly sorted to very poorly sorted, subangular to subrounded; apedal, massive; abrupt, wavy lower boundary |
| 4C3 | 244-268 | 24<br>[208] | **Sandy silt**; yellowish brown (10YR5/4); common medium mottles, pale brown (10YR6/3); silt loam; friable; strongly calcareous; 0% >2 mm; apedal, massive; abrupt, wavy lower boundary |
| UNNAMED TILL (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| 5C4 | 268-283 | 15 | **Diamicton**; yellowish brown (10YR5/4); common fine mottles, strong brown (7.5YR5/6); loam; friable; slightly to strongly calcareous; discontinuously weakly cemented with iron oxide; massive, rough; apedal, massive; abrupt, smooth lower boundary |
| 5D | 283-969 | 686<br>[701] | **Diamicton**; gray to dark gray (10YR4.5/1); stained dark reddish brown (5YR3/2); loam; friable to firm (near base); slightly calcareous; massive, rough; rare to abundant gastropods and pelecypods, common wood fragments; abrupt, wavy lower boundary |
| UNNAMED SEDIMENTS (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| - | 969-994 | 25 | **Silt**; grayish brown (10YR5/2) to dark yellowish brown (10YR4/4) in basal 5 cm; 4-cm sand layer stained with iron oxide (strong brown, 7.5YR4/6); silt loam; firm; slightly to strongly calcareous; sand layer continuously weakly cemented with iron oxide; massive, smooth to laminated; 1% >2 mm; apedal, massive; rare charcoal; abrupt, wavy lower boundary |
| - | 994-1014 | 20 | **Silt**; light yellowish brown (10YR6/4); stained with iron oxide (strong brown, 7.5YR4/6, and dark brown, 7.5YR3/4); silt loam; friable to firm; strongly calcareous; discontinuously weakly to strongly cemented with iron oxide; massive, smooth to laminated; apedal, massive; abrupt, wavy lower boundary |
| - | 1014-1051 | 37 | **Sand**; yellowish brown (10YR5/6); stained with iron oxide (strong brown, 7.5YR4/6); sandy loam to loamy sand; friable to firm; strongly calcareous; discontinuously weakly to strongly cemented with iron oxide; massive, smooth; fine sand, poorly sorted, very angular to subangular; apedal, massive; abrupt, wavy lower boundary |
| - | 1051-1068 | 17 | **Sand**; yellowish brown (10YR5/6); stained with iron oxide (strong brown, 7.5YR4/6); sandy loam or loamy sand; very friable to firm; strongly calcareous; discontinuously weakly cemented with iron oxide; massive, smooth to layered; medium sand, moderately sorted, subangular to rounded; apedal, massive to single grained; abrupt, wavy lower boundary |
| - | 1068-1102 | 34 | **Sand**; yellowish brown (10YR5/6); stained with iron oxide (strong brown, 7.5YR4/6); sandy loam; very friable to friable; strongly calcareous; discontinuously weakly cemented with iron oxide; |

| | | | |
|---|---|---|---|
| | | | massive, smooth to layered; medium to coarse, moderately sorted, subangular to rounded; apedal, single grained; clear lower boundary |
| | 1102-1710 | 608 [741] | **Gravel**; dark yellowish brown (10YR4/4); loose; slightly calcareous; massive, rough; poorly sorted, subangular to rounded; apedal, single grained (description of top 27 cm) |

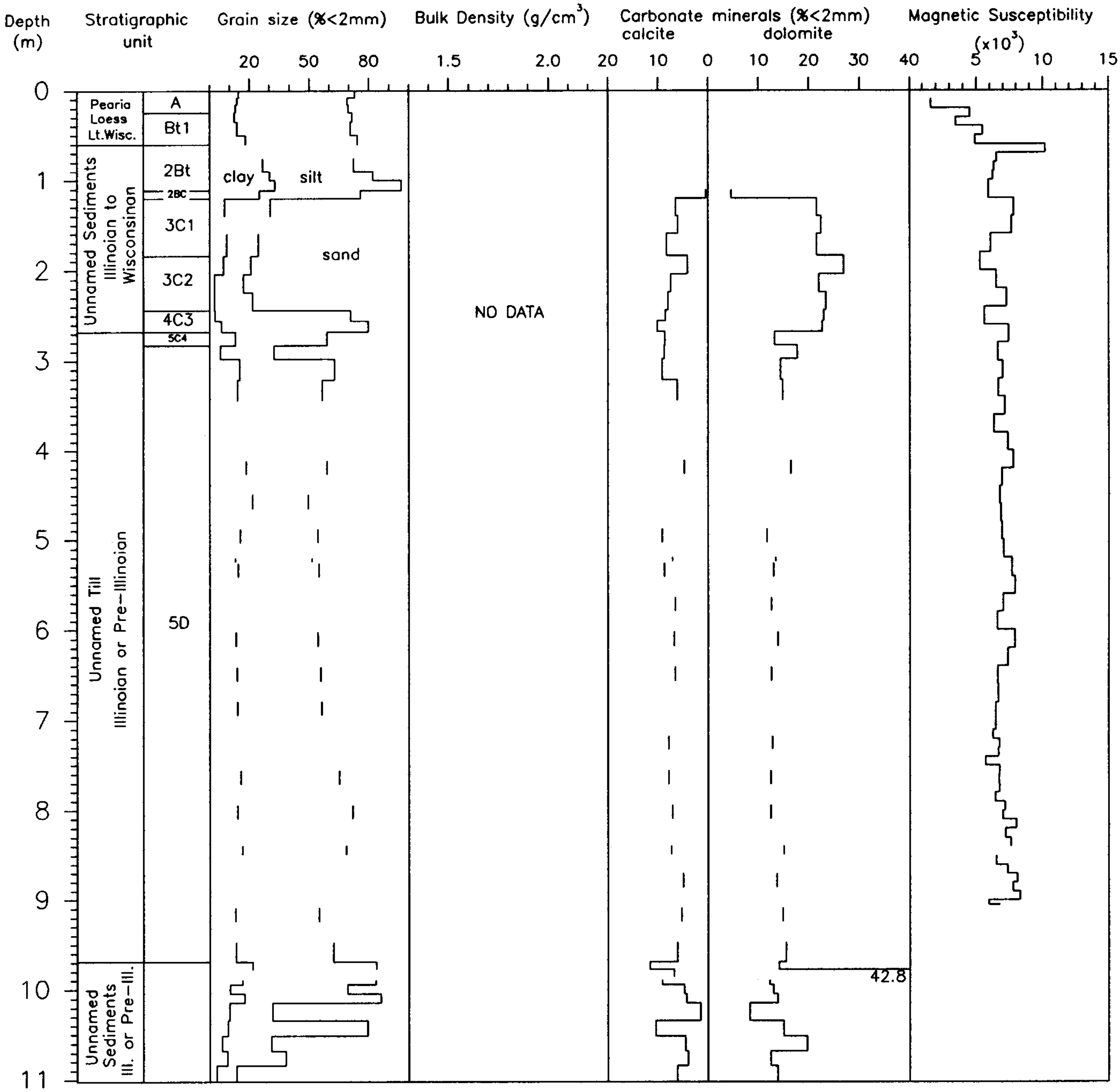


FIGURE 25.—Laboratory data for profile PO-1 to 1102 cm depth (data not collected in gravel below 1102 cm).

## PROFILE DESCRIPTION AND LABORATORY DATA: PO-2
(see also fig. 26)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| UNNAMED TILL (ILLINOIAN OR PRE-ILLINOIAN) | | | |
| - | 0-40 | 40 | **Diamicton**; yellowish brown (10YR5/4); clay loam (upper part) to silt loam (lower part); strongly calcareous; massive, rough; abrupt, smooth lower boundary |
| - | 40-750+ | 710 [750] | **Diamicton**; dark gray (10YR4/1); clay loam to silt loam; strongly calcareous; massive, rough |
| UNNAMED SEDIMENTS (PRE-ILLINOIAN) | | | |
| - | 750+ | | **Clay**; dark grayish brown (10YR4/2); moderately calcareous; apedal, massive; reversed magnetic polarity |

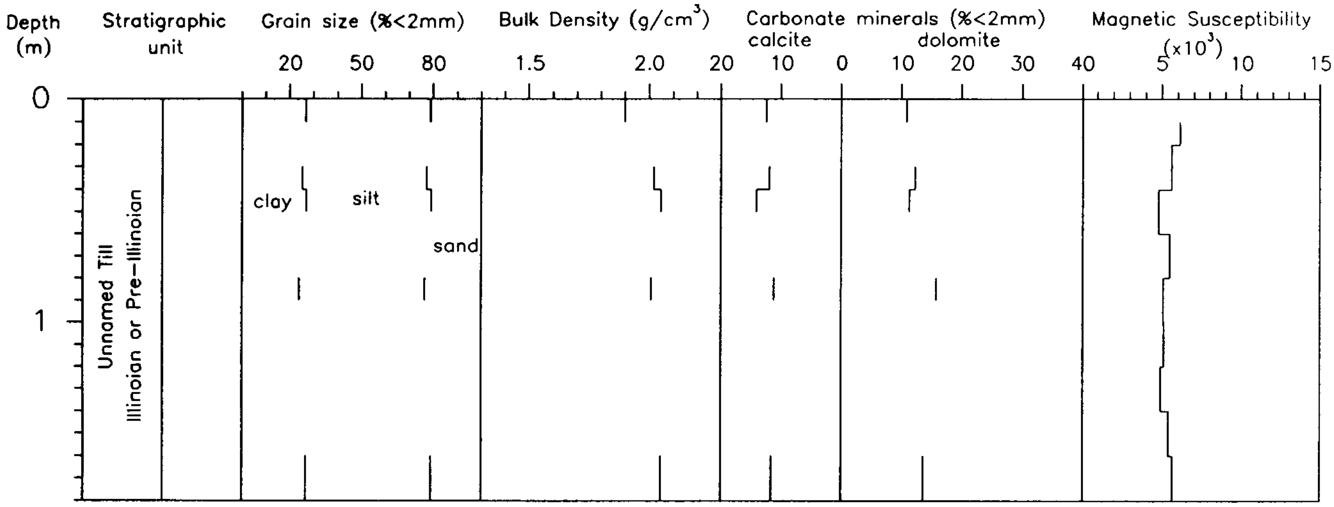


FIGURE 26.—Laboratory data for profile PO-2 to 180 cm.

## PROFILE DESCRIPTION AND LABORATORY DATA: PO-4
(see also fig. 27)

| Soil horizon | Depth (cm) | Thickness (cm) | Field description |
|---|---|---|---|
| PEORIA LOESS (LATE WISCONSINAN) | | | |
| SURFACE SOIL | | | |
| A | 0-40 | 40 | **Silt**; dark yellowish brown (10YR3/4); silt loam; very friable; noncalcareous; massive, smooth; subangular blocky and granular structure; clear, wavy lower boundary |
| BA | 40-53 | 13 | **Silt**; dark yellowish brown (10YR4/4); silt loam; very friable; noncalcareous; massive, smooth; moderate, fine to coarse subangular blocky structure; very few thin clay films on ped faces; clear, smooth lower boundary |
| Bt1 | 53-83 | 30 [83] | **Clayey silt**; dark yellowish brown (10YR3/4); silty clay loam; friable; noncalcareous; massive, smooth; strong, fine angular blocky structure; few moderately thick clay films on ped faces; abrupt, irregular lower boundary |

UNNAMED TILL (ILLINOIAN OR PRE-ILLINOIAN)

SURFACE SOIL

| | | | |
|---|---|---|---|
| 2Bt2 | 83-114 | 31 | **Diamicton**; yellowish brown (10YR5/4); stained with iron (reddish brown, 5YR4/4) and manganese (very dark grayish brown, 10YR3/2) oxides; silty clay loam to clay loam to sandy clay loam; friable; noncalcareous; massive, rough; strong, fine to medium subangular blocky structure; few moderately thick clay films on ped faces; abrupt, smooth lower boundary |
| 2BC | 114-172 | 58 | **Diamicton**; grayish brown (10YR5/2); stained with iron (strong brown, 7.5YR5/6) and manganese (very dark grayish brown, 10YR3/2) oxides; clay loam to silt loam; firm; very slightly calcareous; massive, rough; moderate, fine subangular blocky structure; very few thin clay films on ped faces; abrupt, smooth lower boundary |
| 3CB | 172-174 | 2 | **Sand**; yellowish red (iron stained, 5YR5/8); very friable; noncalcareous; continuously weakly cemented with iron oxide; massive, smooth; 2 to 5% >2 mm, moderately sorted, subrounded to rounded; apedal, massive; abrupt, wavy lower boundary |
| 4C1 | 174-186 | 12 | **Silty sand**; light brownish gray (10YR6/2); stained with iron oxide (strong brown, 7.5YR5/8); sandy loam; firm; slightly calcareous; massive, smooth to rough; 0 to 15% >2 mm, poorly to moderately sorted, subangular to subrounded; weak, medium subangular blocky structure; abrupt, wavy lower boundary |
| 5C2 | 186-205 | 19 | **Gravel**; yellowish brown (10YR5/4); stained with iron (strong brown, 7.5YR5/8) and manganese (black, 10YR2/1) oxides; matrix silt loam; loose; slightly calcareous; massive, rough; very poorly sorted, angular to rounded; apedal, single grained; abrupt, wavy lower boundary |
| 6C3 | 205-249 | 44 | **Diamicton**; light yellowish brown (10YR6/4); stained with iron oxide (strong brown, 7.5YR6/4); silt loam; firm; strongly calcareous; massive, rough; apedal, massive; clear, wavy lower boundary |
| 6D | 249-269+ | 20 [186] | **Diamicton**; light gray to gray (10YR6/1); silt loam to loam; firm; strongly calcareous; massive, rough; rare to abundant gastropods and pelecypods, rare fish and small mammal bones, common wood fragments; lower boundary not reached |

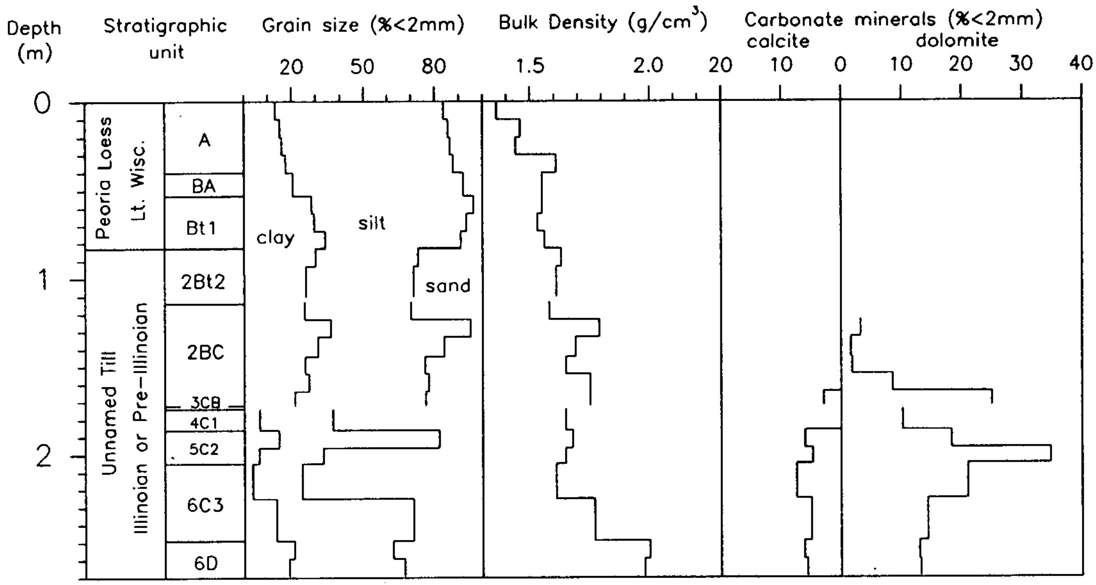


FIGURE 27.—Laboratory data for profile PO-4.

## DISCUSSION

For this locality there are a number of puzzling questions. The section is capped by late Wisconsinan Peoria Loess, and at stream level there are lake sediments with reversed polarity. But what are the ages of the upper and lower tills and the intervening sand and gravel sequence? Why is there no evidence of a paleosol in this section? Why does the upper till contain molluscs, vertebrates, and other fossils? What environment permits the deposition of such a unique till? What is the age of those fossils, and how does that age compare to the age of the till that contains them? Does either of these tills correlate with tills at American Aggregates or New Paris?

## STRATIGRAPHIC CORRELATIONS AND TILLS

by Thomas V. Lowell

Understanding the Sangamonian-Wisconsinan transition requires careful examination of the several glacial and nonglacial sediment packages that bound it. In the Miami Sublobe, as elsewhere, very few Quaternary sequences are complete, thus raising the age-old question of how to correlate between sections. Radiocarbon age estimates provide reliable insights no earlier than the advance of the late Wisconsinan glaciers. To understand and correlate the late Wisconsinan, Sangamonian, and pre-Sangamonian record, we contend that it is critical to examine sections with a view toward reconstructing regional events; further, we believe these events have left, in valleys, a correlatable signature. Historically, workers in the Miami Sublobe have depended heavily upon two avenues of correlation: interpretation of paleosols and tills. Paleosols are considered elsewhere in this guidebook, and correlation of tills in valleys is discussed here.

Tills make up the bulk of Quaternary sediments in the Miami Sublobe, and there have been many attempts to correlate them. Most past efforts have been based on matching physical properties such as measures of grain size, fabrics, clay mineralogy, and clast lithology. These properties are partly helpful, but many former workers in the Miami Sublobe relied on these criteria exclusively and met with frustration (table 3; also see discussion in Goldthwait and others, 1981). The physical properties of till vary and depend on the bedrock or other material over which the glacier has traversed and the exact processes by which the sediments were deposited.

TABLE 3.—*Lithologic properties used for correlating tills in southwestern Ohio and southeastern Indiana*

| Author[1] | Property[2] A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Blackman, 1970 | | n | | p | n | | n | | n | |
| Brace, 1968 | | n | y | y | n | | y | | | |
| Crawford, 1977 | p | p | | | p | n | p | | p | |
| Franzi, 1980 | n | p | | | | | n | | | y |
| Goldstein, 1968 | n | n | y | n | | | p | n | | |
| Guccione, 1972 | p | p | y | | | | | | | |
| Holmes, 1974 | n | n | y | n | | | | | | |
| Neale, 1979 | n | p | | | | | | | | |
| Newdale, 1980 | y | y | n | | | | p | | | n |
| Oldfield, 1977 | n | n | p | n | | n | n | | | |
| Pritchard, 1980 | n | | | | | | | | | n |
| Reddin, 1981 | n | p | y | n | | | p | | | |
| Soller, 1978 | n | p | | | | | n | | | |
| Spitzer, 1979 | p | | y | | | n | n | | | |
| Sun, 1975 | | p | | n | | | | | | |
| Thomas, 1965 | | n | y | n | n | | y | | | |
| Watson, 1972 | | n | y | p | n | | n | | | |
| Wright, 1970 | | | n | n | n | | n | | | |

[1]Authors, all students of D. P. Stewart, Miami University, reported varying degrees of success in correlating tills: n = not successful; y = yes, successful; p = partly successful; blank = property not studied.

[2]Key to properties: A, carbonate; B, clay mineralogy; C, clast fabric; D, grain size; E, heavy minerals; F, magnetic susceptibility; G, pebble lithology; H, roundness; I, sand lithology; J, trace elements.

A second approach has been to simply count units above or below a known interval, thus establishing a given till's position in the stratigraphic sequence. In some cases, this suffers from circular reasoning. If, for example, we count up three tills from an organic horizon, we always get the such-and-such till. As a corollary then, assuming we have the same till at two sections, we could claim that a paleosol two units down from the till is the same, but this may not be true. There are at least three weaknesses with a unit-counting approach: (1) erosion may remove one or more units, (2) till units commonly are not deposited continuously, and (3) units may change character over distance.

Erosion can be difficult to identify within a glacial sequence unless the unconformity cuts across several units. At Oxford, Ohio, Ekberg (1991) reported a major unconformity that lies on bedrock, gravel, lacustrine clay, and a till. Above the unconformity lies loess and the late Wisconsinan sequence of tills. Given the extensive nature of the erosion at Oxford, it seems likely that any soil developed on the till would have been removed. Without this insight one might conclude that the hiatus between deposition of the two tills was brief because no soil had been found between them.

Any one identifiable till unit is unlikely to be present over a wide areal and stratigraphic range. One reason, with important stratigraphic implications, is that a single glacial advance and retreat may produce several facies of till. Using the terminology of Dreimanis (1989) and Elson (1989), an advancing glacier may deposit lodgement till (accumulation of debris by plastering-on as the glacier moves) and/or deformation till (admixture and transport of rock or unconsolidated sediment with primary structures distorted or destroyed). Glaciers that have stopped may form meltout till (debris deposited by slow release as the ice melts) or sediment-flow deposits (material that has been reworked one or more times by gravity-driven processes). Both meltout till and sediment flows may occur in subglacial or supraglacial positions. Additionally, glacial meltwater may create a variety of water-worked stratified sediments. Lawson (1979, 1982), Eyles and others (1982, 1983), Dreimanis (1984), Shaw (1987), and Levson and Rutter (1989) give more specifics on these processes and, importantly, some possible relationships between different types of tills or till facies.

A traditional approach to till correlation has been to consider the units within a sequence of several till units as largely separate, unrelated entities. However, we argue that for correlation purposes it may be better to identify an entire sequence of related glacigenic sediments, including till facies, that result from a single advance and retreat. To this end, we need to consider the genesis of each till unit and construct a facies model.

In the Miami Sublobe, Ekberg (1991), Savage and Lowell (1992), and Savage (1992) have investigated late Wisconsinan-age tills using a genetic/facies approach. From this data set, additional observations at many other sections, and the assumption that older glacial advances in the Miami Sublobe produced similar sequences, we suggest a provisional till facies model for this area.

We first note that the distribution of Quaternary sediments is not random; rather, thick sections, as the ones described in this guidebook, are preferentially located in valleys. The valleys may be either small or large and have been exhumed (otherwise we would not even see the sections!). These valleys appear to act as small basins to preserve more detailed records of glacial events. We subdivide the valleys by orientation—either away from the general direction of glacial flow, which allows free drainage during the ice advance, or into the ice flow, which creates a localized ice-dammed lake.

For the free-draining valleys (fig. 28), we suggest that processes preceding an advancing glacier first introduce colluvium and loess over the former soil (paleosol) of the valley, and then form a localized lake. As the glacier advances over a given site, it deposits a complex of sediment flows and then a lodgement till. This sequence may also contain incorporated and transported underlying sediments. The recession sequence is simpler but thicker; meltout tills give way to a complex of subaerial sediment flows and finally stratified sediments. In the ideal, uneroded sequence, soils then develop within a parent of sediment flows and/or stratified sediments.

For the blocked valleys (fig. 28), proglacial processes again cause colluvium and loess to be deposited over the local soil (paleosol). Lacustrine sediments form as the valley is blocked. These sediments are interbedded with subaqueous sediment flows that increase in number upsection as the glacier advances farther into the basin. Finally, a lodgement till marks passage of the ice margin. Recession follows with interbedded lacustrine materials and subaqueous sediment flows accumulating as long as the lake remains dammed. Soils develop in the upper lacustrine unit.

Lodgement tills of subsequent readvances into either valley-orientation type are extremely clast rich. The uplands are stripped of older sediments and are interpreted to be a major source of the clasts (Ekberg, 1991).

These ideal sequences are rarely complete at any one site. Commonly, readvances or nonglacial erosion remove parts of the sequence, and soil development may begin upon any exposed unit. For example, the late Wisconsinan advance-and-retreat sequence might be represented by three till units at one location and five units at another; the package may be correlated within one sequence by comparison to the facies model. The model accommodates lateral pinchout of units and facilitates correlations.

A facies model is useful beyond identifying the tills and related sediments of a single advance-and-retreat sequence; it can be used to identify the number of advances and retreats in an area. We can count the number of glacial advances by the number of sequences we find. These sequences may be placed within a stratigraphic context depending on their associations with each other, paleosols, or other nonglacial marker beds.

In conclusion, for correlation of tills, we advocate scrutiny of glacial sequences in their thickest parts, that is, in paleovalleys. However, future efforts must also be directed toward fluvial, slope, eolian, and pedogenic materials; they, after all, represent the longest portion of the Quaternary record in the Miami Sublobe.

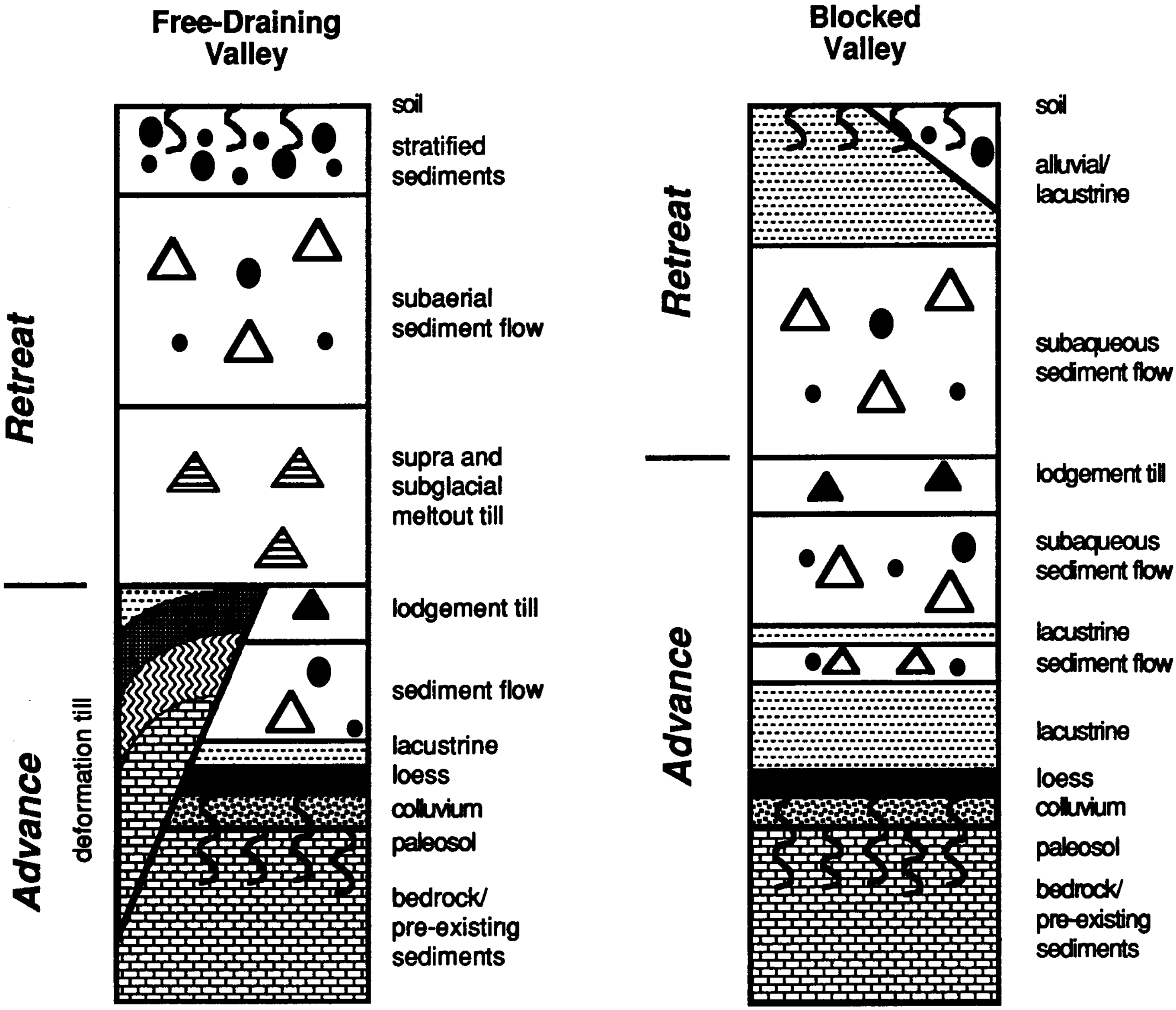


FIGURE 28.—Idealized facies relationships of a single advance/retreat cycle in valleys in southwestern Ohio and southeastern Indiana.

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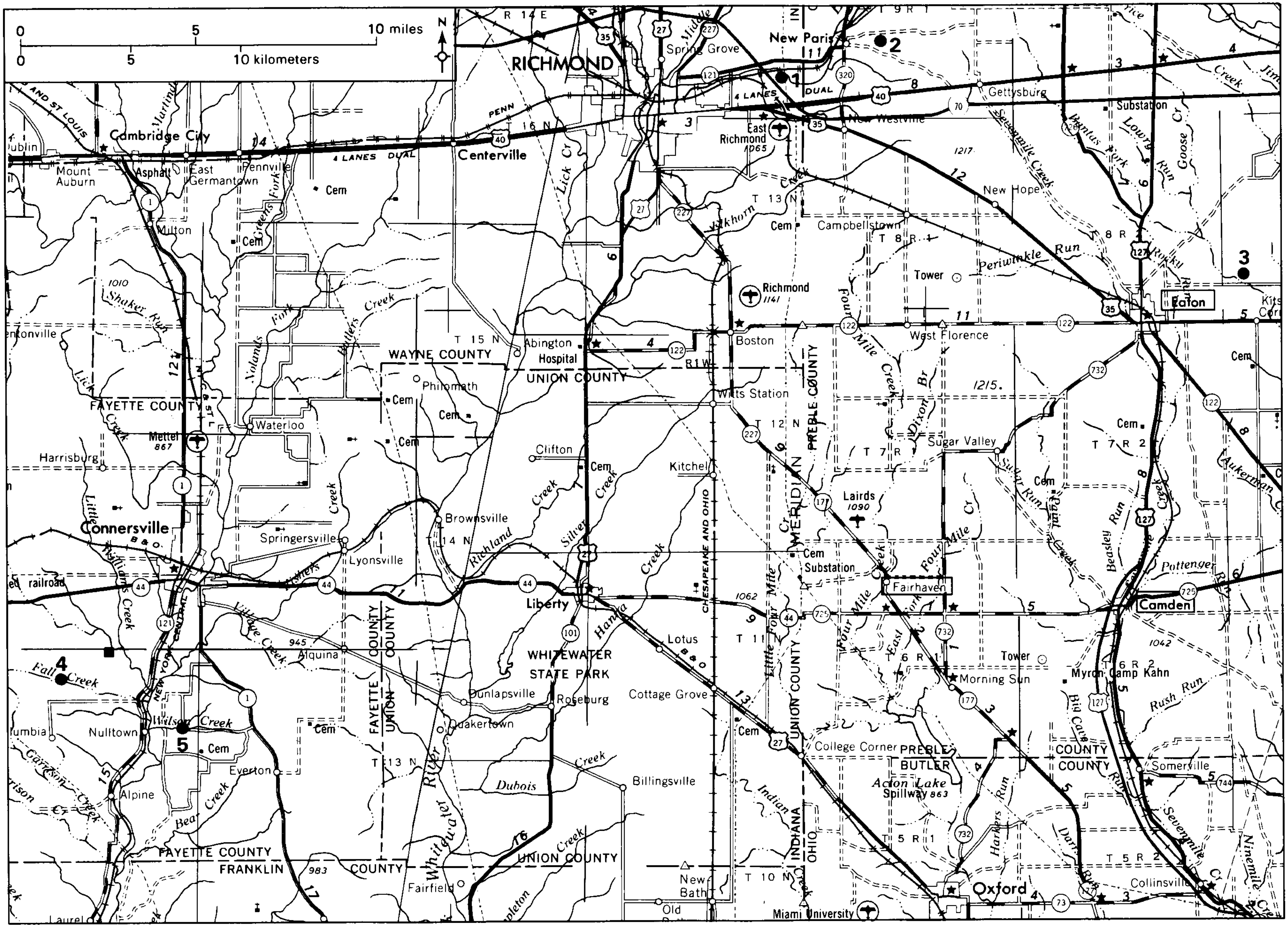


Map of field-trip stops 1-5 (solid circles) and optional stop (solid square).